THE SCIENCE OF THINGS ABOUT US

RUSH AND WINSLOW

Dist. 48

THE SCIENCE OF THINGS ABOUT US

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NATIVES STRIPPING BARK FROM CORK TREES IN ALGERIA

THE SCIENCE OF THINGS ABOUT US

BY

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INTRODUCTION

CHILDREN are always asking questions. They wish to know, and they wish to know *why*. It is one of the main functions of the school to satisfy their questions, to provide answers for the inquiring mind, and to stimulate and give direction to further inquiry.

This little book gives a natural, simple, and yet scientific explanation for the everyday occurrences of home and school life, and by its method of development encourages children to think intelligently about matters which are more remote. It makes them wish to know — and helps them to find out. In its method of treatment it is an excellent example of good teaching, proceeding from that which is simple and near at hand to that which is more complex and more remote. It arouses interest, stimulates inquiry, and offers just enough help so that by reasonable effort the problem can be solved. Dealing with questions which have a direct relation to life, and which in their solution satisfy a felt need, it uses the information thus obtained to attack new and more difficult problems. Thus by an ever-widening circle the bounds of knowledge and power are extended to the conquest of worlds unknown.

Intelligence and skill are developed, and education takes place.

The authors of the book have been mindful of the words of Pestalozzi to the effect that the end of instruction is to make ideas clear. The style of treatment is simple and direct, and for the most part expressed in terms with which the children are familiar. When a difficult scientific word is introduced — as it is occasionally, because there is no other that quite conveys the meaning — there will be the satisfaction that comes from a new word added to one's vocabulary. Children take delight in the use of "hard words," if they are not too many and if their meaning is not obscure. The material of the volume provides new information upon familiar subjects and furnishes an interesting series of problems for class or group discussion. The friendly excursions into factory and mine, workshop and forest, are presented in story form, and should cultivate the imagination as well as the vocabulary.

In spite of a natural and eager curiosity, children must be stimulated to observe what is taking place about them. If they begin early to ask Science for her explanations of what they see happening at school and at home, on the playground and on the streets of the city, or along the country roads, scientific understanding will later be made an active force in their processes of learning. That is the purpose of this book: to create a desire for scientific knowledge; to stimulate the creative imagination; and to direct the pupil and teacher to true sources of information.

While *The Science of Things About Us* is a science

reader, it is much more than that. It is a book which in the hands of a good teacher will open the windows toward truth, that the clear light may shine into the dark places, and that understanding and reverence may take the place of superstition and mystery. There are books of information, books of appreciation, books of inspiration — and a few, but not many, which answer all these ends. Happy that book which, based upon scientific facts, explains them in such a manner that information, appreciation, and inspiration at once are the outcome.

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PART I

IN THE SCHOOLROOM

HOW THE WASP TAUGHT US TO MAKE PAPER

ACCORDING to an old, old legend, the Chinese first learned to make paper by watching the wasp build her nest. The big round nest of the wasp is really made of crisp brown paper. A Chinaman, watching the wasp one day, discovered that she took a bite of wood, chewed it into paste, and smeared it on to her nest. When the paste became dry it turned into something like our paper. Thus the Chinese learned to make paper from wood long before any other people in the world. They also discovered how it could be made from cotton.

Many thousands of years ago the people of Egypt made paper of the papyrus plant which grew along the banks of their great river, the Nile. They cut the stalks of the plant into strips, which they then made into a layer by placing them side by side. Across this layer a second one was formed by placing strips in the opposite direction. Heavy pressure made the fibres of the plant stick together, and when thoroughly dry a sheet of fairly good paper resulted.

Later on, the Greeks and Romans learned to make a writing material called parchment or vellum, from the skins of lambs, calves, and kids. After the Chinese

way or making paper was learned by the people of Europe, parchment was used less and less. Paper was at first made by hand by a very slow, crude process, but toward the end of the fifteenth century a paper mill was set up in Germany and paper began to be made by machinery.

Paper can be made from any kind of vegetable fibre which will mat together, but cotton and linen fibres are best. In England a kind of Spanish grass, called esparto, is used a great deal for paper-making. This makes a light, spongy paper. In the United States wood is used more than anything else, the wood of poplar, chestnut, spruce, fir, balsam, and pine trees being suitable for paper. Hemp and straw are also used a great deal.

To make paper of cotton or linen fibres, old rags are used. Many of the rags collected by the "old-clothes man" from your back door are made into paper. The rags when received at the paper mill are carefully sorted to remove buttons, pins, hooks and eyes, and other things not wanted in the paper machine. They are then cut into small pieces and beaten in a big drum to remove loose dirt and dust. They still look very dirty, however, and rags of all colors are mixed together. So they are boiled for hours to remove the dirt and are bleached with chloride of lime to take out the dyes. This makes them white and clean, and they are ready to be beaten into a paste or pulp. This process takes place in a huge beating machine, which is fitted with knives on a big wheel like a paddle wheel. In this machine fine clay is often added to the pulp to act as a

filler, that is, to give the paper a smoother surface. "Sizing" or rosin may also be added to give the paper a glossy finish. The beating lasts several hours, and the finer the grade of paper to be made the longer it must be beaten. From the beating machine the pulp is run into vats or tanks ready for the real paper-making machine.

Other vegetable fibres must be changed into pulp also before they are ready for paper-making. Two methods are used for making wood into pulp. Ground pulp is made by holding blocks of wood against whirling grindstones over which water is constantly flowing. The water carries the ground bits of wood to huge sieves where the coarse pieces are separated and the remaining mixture is then stored in vats ready for paper-making. This method of grinding breaks the fibres into such short pieces that the paper made from them is not very strong or tough. It is used only for cardboard, packing paper, and a cheap quality of news-print paper.

By the other process the wood is cut into chips and is cooked for several hours in a tank with certain chemicals which eat up everything but the fibres wanted for paper. This makes a much better kind of pulp and most papers to-day are made by the chemical process. Book paper, news-print paper, and most writing papers are made from chemical pulp.

The paper-making machine is very complicated and very wonderful. It is sometimes more than one hundred and fifty feet long and carries the wet, milky-looking pulp through many processes until it comes out in a wide ribbon of smooth paper. From the vats where the pulp is stored the material is forced into the first section

of the machine. This is a kind of screen or sieve which shakes and jostles the fibres until they are well matted and tangled, the water passing out through the holes in the screen. From here the wet paper — for that is what it is now — is passed in a continuous strip over felt-covered rollers or belts to hot cylinders or rollers which dry it, and then over cold iron rollers which smooth it. Finer papers, before being passed between the cold rollers, are given a bath in a solution of gelatin, which produces a fine, soft finish. The finished paper is either wound from the machine into rolls for newspaper printing, wrapping paper, and so forth, or is cut into sheets by the machine.

Pure rag-papers are rather rare to-day. Bank notes or paper money are made of pure linen fibres mixed with silk, and so-called bond papers are usually of cotton and linen mixed. But rag pulp is often mixed nowadays with wood pulp to make a very good grade of writing or book paper. Tissue paper, which seems so strong and tough for its weight, is usually made of hemp and rags. Hemp is a plant which has very tough fibres.

Blotting paper is a spongy paper made without any sizing. Waxed paper is a thin paper which has been passed through a bath of melted paraffin to make it waterproof. Carbon paper, which is used in typewriters for making extra copies of articles typed, is made by giving paper a coat of a mixture containing starch, gum, flour, and a black or blue coloring matter.

New uses for paper are being invented all the time. Paper pulp is used a great deal for making *papier maché*.

The pulp is mixed with glue, paste, or some substance to hold it together and is pressed into moulds until dry. It is tough and strong like wood, and many useful articles may be made from it. It is used for making dishes, boxes, pails, washtubs, flower pots, light-weight furniture, and recently it has even been used for car-wheels. How many uses for paper can you think of which have not been mentioned?

THE STORY OF BOOKMAKING

You may think that books had to wait for the invention of paper before they could be made. It is very hard to think of a book made of anything but paper. But books existed long before paper was known. In fact, as soon as man invented writing he began to write down his thoughts in some way which would preserve them. The stone tablets on which he first told his thoughts by drawing pictures may really be called the first books.

Many old libraries have been found in the countries of the East, where the books were all made of clay tablets or bricks. The writing was done with a pointed metal tool or "stylus," while the clay was still soft. The tablets were then baked, and in dry countries where there is little rain or moisture they have lasted thousands of years. In Egypt, where paper was first made of the papyrus plant, books were in the form of rolls, the paper being wound on rods like our wall maps. Books written on parchment were at first rolled also; but later the parchment was cut into sheets which were tied together at one side. Then books began to look a little as they do to-day.

For many hundreds of years books had to be written entirely by hand, as printing had not been invented. Some of those old handmade books — manuscripts, as they are called — are still to be found in museums and great libraries. Many of them are very beautiful. During the Middle Ages they were written by the monks, who often spent an entire year writing a single book. To make the books more beautiful, capital letters were often ornamented with gold and brilliant colors, and the bindings decorated with gold, silver, or precious stones.

In those days books were of course very scarce and expensive, and not many people could own them or even see them. Most of the people could not read, and knew very little about the rest of the world. But the invention of printing changed all this; for then books could be made more rapidly and many copies of the same book could be made at a low price. At first a whole page of a book was printed from a single block of wood. The block was carved, so that the letters would stand out, and when covered with ink it would print a sheet of paper. But this was a slow way of printing, for it took a long time and a great deal of labor to carve the block for a single page, and each page had to have a separate block.

What we now call printing was probably invented about 1450 by a man named Johann Gutenberg. He decided that the work could be done easier and faster if each letter of the alphabet were made of a separate piece of wood and the letters put together to make words. So the first "type" was made. Later the

shape of a letter was cut, probably, on a small bar of steel or iron, which was hardened, then pressed into plaster or some soft metal, making a hollow mould in the shape of the letter. Melted metal (mostly lead) was poured into this mould and allowed to harden. When removed from the mould, this bit of type was ready for printing. The various letters were put together in words, the type being held in place by strips of metal. When a page was all set up, or put together, it was fastened to a flat surface on the printing press. The type was inked, and sheets of paper were then pressed against it.

Gutenberg and the men who helped him kept their process a secret for several years, and when people learned how quickly and cheaply these men were making books they were suspected of being magicians. People thought the red ink they used for some of their printing was human blood.

The first whole book ever printed on Gutenberg's press was the Bible in the Latin language, and it was completed in 1456.

Since that time, over four hundred and fifty years ago, many improvements have been made in printing processes. To-day type is made or "cast" by machinery instead of by hand, and can be made much more rapidly. A machine can turn out 30,000 pieces of type in a single day.

A visit to a modern bookmaking shop where books are printed and bound is a very interesting experience. Books must first be written by the author, who usually sends them to the printer in the form of a neatly

typewritten manuscript. The manuscript is given to the compositors or men who set the type. Some typesetting is done by hand. The type is arranged in large cases which are divided into little square sections, each section containing type for only one letter of the alpha-

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COMPOSITORS AT THEIR CASES SETTING TYPE BY HAND

bet. The compositor stands before his case and sets the type in "sticks," which are little metal trays with a slide at one side for holding the type in place.

Machines have been invented for typesetting and are nowadays largely used for bookmaking and newspaper printing. These machines are operated somewhat like a typewriter; but instead of simply setting the type in place they actually make it when a certain letter is

punched. The linotype machine makes a whole line of type at a time, while the monotype makes separate letters.

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EXAMINING SHEETS ON WHICH SEVERAL PAGES HAVE BEEN PRINTED AT ONCE

When the manuscript has been set up, the type is placed in the printing press and pages of the book are printed. First of all a "proof" sheet is printed, which is sent to the author for proofreading, that is, to see if any mistakes have been made in the typesetting. Several pages of a book are printed on one sheet of

paper, usually either sixteen, thirty-two, or sixty-four, depending on the size of page wanted and the size of the paper. The modern printing press is so wonderfully made that it will print and fold such sheets without any help from the printers, sometimes doing more than 10,000 copies in an hour.

When the pages of the book are all printed and folded, the book must be put together and bound with a cover. The different sheets which have been folded into pages are called signatures. These signatures are put together in their proper order, so that the pages of the book will be in the correct places. The book is then pressed to make the leaves lie tight and straight, and the signatures are sewed together. This is usually done by girls who are very clever at their work and know how to sew the book securely so that it will not easily come to pieces. Some sewing is now done by machine but the hand sewing is usually better.

The edges of the book are then trimmed with sharp knives and the book is put into a press and "rounded"; that is, the back is made to curve outward, so that the book will hold its shape better when it is opened. The covers are then glued on — another process which is now done almost entirely by machinery. If the sides are to be covered with paper this, too, is pasted on by machinery. In case the cover is to have a gold design and lettering on it, these are put on before the cover is glued to the book. The gold is placed on the cover in the form of a thin sheet called gold leaf. A hot brass stamp, which has been engraved or carved with the design and letters, is then pressed on the cover, and the

gold sticks tightly wherever the stamp touches it. The rest of the gold leaf is rubbed off with a kind of rubber eraser. When the binding is completed the book is placed in a press which holds it very tight until the glue is dry, and gives it the neat shape which new books always have.

King Solomon, the wise ruler in the Bible story, once said, "Of making many books there is no end." We know that in his day it took a long time to make a single book, and in the whole world there were probably not so many books as there are now in one large library. King Solomon would be much astonished if he could see the thousands and thousands of books which come from our printing presses each year. The making of books in such large quantities that almost anyone can afford to buy them is one of the most wonderful things which happen in our world to-day. Books teach us what other people have thought and what they have found to be true. They teach us all the wonderful things which people in past ages have done. They give us knowledge. They inspire us to do better and bigger things. Think how unfortunate we should be to-day if there were no more books in the world than in King Solomon's time!

WHAT IS A LEAD PENCIL?

When we speak of lead pencils we really do not mean "lead" at all, for there is no lead in the pencils we use to-day. Centuries ago, among the Romans and other early peoples, sticks of lead were used for writing. Pencils were really lead pencils until about 1564, when a

new material was discovered in England which made a much softer, blacker mark than lead. This material was at first called "black lead," and when pencils were made of it they were still called lead pencils.

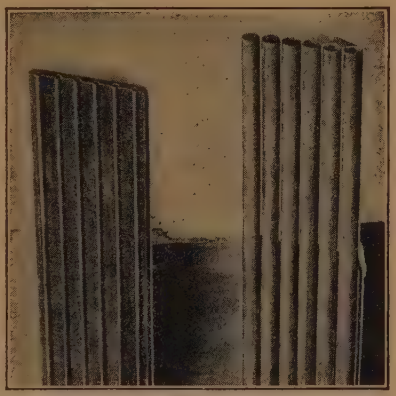
Graphite is the real name of this new substance. It is found in the earth and must be dug out or mined like coal. It is black or grayish-black. When the first mine was discovered in England it was considered so valuable that for a long time soldiers were set to guard it.

Graphite is almost too soft to use alone in pencils. It is therefore mixed with a very fine, soft clay, the best kind being found in Austria and Czechoslovakia. The hard pencils contain a great deal of clay, while the softest, blackest pencils contain very little clay and may even have some lampblack added to deepen the color. To prepare the mixture of clay and graphite it must be ground and ground until it is the very finest powder and even after that it is sifted through fine silk sieves.

This fine powder is then mixed with water until it looks like black cream. This is also ground for a long time between millstones, and some of the water drains off. The mixture, which by this time looks somewhat like black dough, is squeezed through holes in a press until it is quite smooth, and is finally run through a press which has just one hole in the bottom as large as the lead required for the pencil. The dough comes out of this little hole like a long black worm. It must then be handled very rapidly, for it dries quickly. It is laid out straight on a table and is cut into seven-inch lengths, just long enough for each pencil. These wet leads are then sent to a very hot oven where they are baked for

several hours. This is the last process before putting them into the wooden cases.

The cases or wooden coverings of our pencils are generally made of a fine red-cedar wood which grows in the southern United States. Such great quantities of this wood have been used for pencils that the tree is becoming very scarce, and for this reason other kinds of wood are now being used to a certain extent; but none are so good as cedar. To save the wood, many pencils are now made of paper, which is wound about the leads in spiral form.



Courtesy of Eberhard Faber, New York

LEAD IN GROOVES; PENCILS CUT APART

The cedar wood is brought to the pencil factory cut into small slabs half as thick as a pencil, about seven inches long, and wide enough to be cut into six pencils. These slabs are run through a grooving machine which cuts six narrow grooves just large enough to hold the leads. The leads are laid on one slab, and another slab, also grooved, is glued on top. The six pencils, which are thus fastened together in one piece, are put into a press and held tightly until the glue is dry. By means of other machines the six pencils are now cut apart, trimmed until they are round, oval, or six-sided, rubbed until they are smooth, dyed with some color, and

finally varnished. A sort of printing or stamping machine marks each pencil with the name of the maker and the number or letter which shows whether it is hard, medium, or soft. Erasers are put on by machines which press tightly to the pencils the little nickel caps for holding the rubber.

Colored pencils are made by mixing clay, chalk, or wax with some sort of coloring matter and using it in place of graphite. Carpenters' pencils, which are very soft, are made by mixing wax and tallow, instead of clay, with the graphite.

Many millions of pencils are manufactured in the United States each year. It is said that every person in the country could have eight pencils a year without using up the supply. Enough pencils are made in the United States annually to reach around the whole earth three and a half times.

FEATHERS AND FOUNTAIN PENS

Ever since man learned to express his thoughts by marks or writing he has used some kind of pen, though the first pens were called by different names. In the earliest times man did his writing on stone or on slabs made of clay. For this purpose his pen had to be made of some hard metal, such as iron. Later he learned to spread a thin layer of wax over a surface of wood or stone, and did his writing on this. His pens were then made of sharpened bones or some sharp piece of metal, such as bronze. When he began to make a kind of paper from grasses he used for pens small reeds or rushes which were sharpened to a point. Reed pens

are still used in Persia and some other countries in the East.

When real paper was invented man found that he had to have a pen made of some softer material. He then began to use the quills or feathers of geese or swans. The hard, stiff end of the feather was used for writing, being sharpened and split so that it would hold the ink. The other end served as a handle. The Latin or Roman word for feather was *penna*, and it is from this word that our name "pen" comes. The points of quill pens soon wore off and became blunt or broken, so that they had to be sharpened frequently. For this purpose small knives were used, and even to-day we still say "penknife" when we mean a small pocketknife.

Quill pens were used for many hundreds of years. When the first attempts were made to use steel for pens they were shaped to resemble quills, and the handles were all in one piece with the points. About 1820 the first separate steel pen-points were made, but they were so hard to make and were so rare that they were very expensive, costing two or three dollars apiece. With the introduction of better machines for making pens they became much cheaper and more plentiful.

The very finest kind of steel is used for pen-making. It comes to the pen manufacturer in thin sheets about one-fortieth of an inch thick. These are cut into strips just wide enough for two rows of pens. The strips are softened by being put into iron boxes and kept at a very high temperature for several hours. They are then rolled between heavy rollers until they are thin enough to be used for pens. This process requires a

great deal of care, as the strips must be of even thinness all over. A machine then punches these strips into pieces the shape of a pen, cutting from each strip two rows of pens with the points interlapping. This causes very little waste in the cutting. The central holes in the pen-points are then punched out by another machine, which at the same time cuts the little slits from each side of the pens.

After being softened by another heating process, the pens are stamped with the name of the manufacturer and are sent through a press which curves the small flat pieces into the regular pen-shape. They are now too soft to be used for writing; but by two or three processes of heating and cooling they are made hard, tough, and elastic or springy. By means of a very accurate machine the slits are then cut in the points. This is a delicate process, as the slits must be cut in exactly the right places. The points are then ground and slightly rounded, and the pens are polished and smoothed by being tumbled about in a barrel of fine sand or sawdust. They are then carefully examined, and any imperfect ones are thrown away. Some pens are lacquered or varnished to keep them from rusting, and others are given a bath in a solution of gold, silver, or bronze before they are packed.

Steel pens will rust and wear out after they have been used for a time. Gold pens will last forever if well cared for. They are made very much like steel pens, but have at the point a bit of iridium and osmium melted into the gold. These are very hard metals which do not wear off at the point as would the soft gold.

Fountain pens are made with hard rubber holders and gold pen-points. A rubber tube holds the ink inside the pen, and by a very clever invention lets it out only when the pen is writing and in a thin stream just large enough to make a mark. Fountain pens were made as early as 1835, but they were not successful until about fifty years later. Many improvements have been made in fountain pens. Perhaps the most popular is the self-filling pen, which sucks ink up into the little rubber tube inside the holder or barrel. For the self-filler the pen does not need to be opened for filling, and the little glass ink-dropper is not necessary.

HOW FISH AND INSECTS MAKE INK

MANY experiments have been made by man in an attempt to find a perfect writing-ink. When you use ink you want it to flow smoothly from your pen and to dry without smearing or spreading on the paper. Another important need is that the color of the ink shall last a long time without fading.

Inks have been in use for many centuries. In writing their books on papyrus the Egyptians used a kind of ink which can still be read, although it is over four thousand years old. That ink was probably some kind of soot or lampblack mixed with glue.

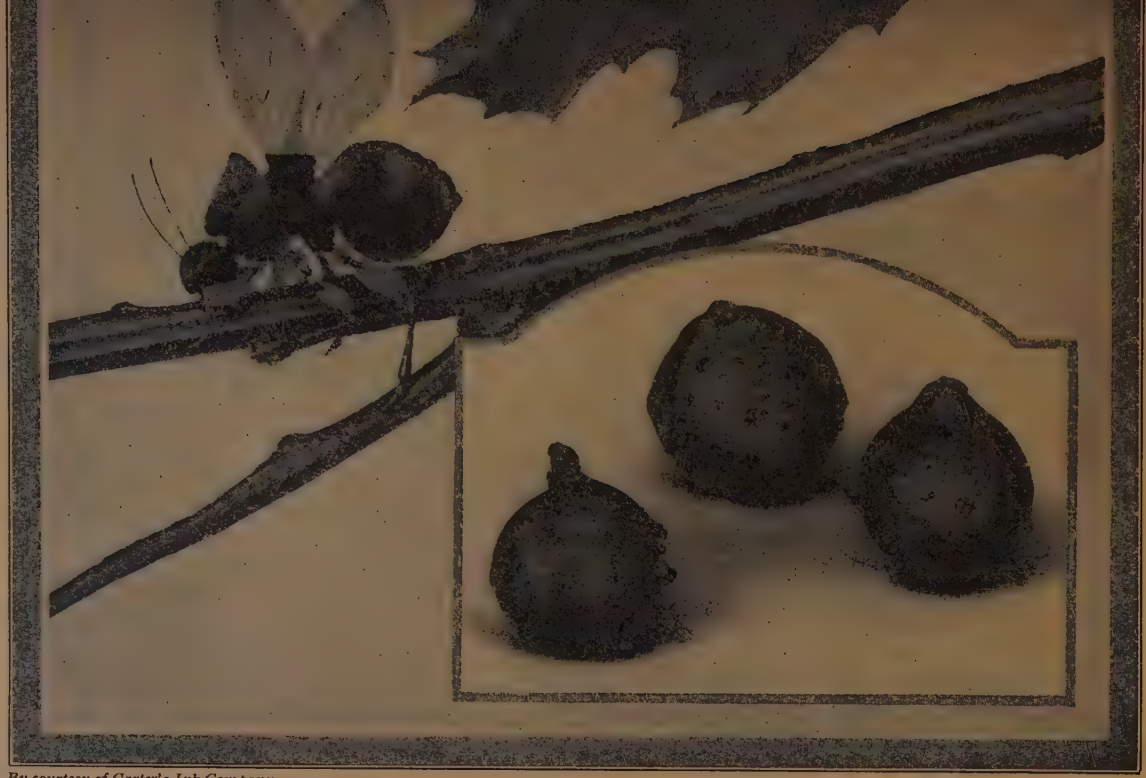
Many hundreds of years ago man made the interesting discovery that he could get a very good ink by using nutgalls. You have probably seen sometimes queer little lumps on the limbs or leaves or trunks of trees, which look as if they did not belong there. Perhaps someone has told you that they were caused by insects.

There are many kinds of gall insects or flies which pierce the bark of trees and lay their eggs there. The trees do not like the feel of this treatment and lumps or knots soon grow over the spots where the eggs have been laid.

In Asia Minor there is a special kind of oak tree on which the eggs of the gallfly produce lumps or nutgalls which are used in ink-making. These nutgalls, which contain a great deal of tannic acid, are cut from the trees, crushed, and soaked in water for several days. The liquid is then poured off and a solution of a chemical called green vitriol is added. The two substances change when put together, and the new substance which results makes good ink. Mucilage is added to thicken it a little, and a bit of acid is used to keep the ink from growing mouldy. This ink is smooth, it does not spread on the paper, and instead of fading it becomes darker with age. It seems strange that hundreds of years ago man should have discovered the best ink which has ever been made.

Many inks are made to-day from the wood of a Central American tree called logwood, and from other woods which contain tannic acid. Artificial dyes are also used a great deal in making inks. But none of these inks last as well as the nutgall ink. They all fade in a few years. Fountain-pen ink is made from an artificial dye, because it is particularly smooth and does not become thick when it has been in the pen a long time.

The brightest red inks are made from cochineal, a dyestuff found in the bodies of tiny insects which live



By courtesy of Carter's Ink Company

GALLFLY AND NUTGALLS USED IN MAKING INK

on the cactus plants of Mexico and South America. The insects are scraped off, placed in a hot oven or in boiling water to kill them, and then are dried thoroughly in the sunshine. The little bodies are then dissolved in ammonia water to make a red paste which is used in red inks.

A very interesting dark-brown ink, called sepia, is made from a fluid found in the cuttlefish. This fish may have given us the idea for the smoke screens which were used in the World War. At any rate, he carries beneath his body a bag full of dark-brown liquid. When he feels himself in danger and wishes to hide, he sends out a big cloud of this liquid, which so darkens the water all around him that he can get away unseen. From this liquid the sepia ink is made. It lasts longer than any other ink known.

Printing inks, which are used on printing presses, are much thicker than writing inks. The black inks are generally made of some kind of soot, such as lampblack or gas black, mixed with oils, principally linseed oil, and other substances which give it the proper qualities. You have no doubt noticed how soot collects about a fireplace or on a lamp chimney. This is because the flame does not have enough air to burn all the fuel. Lampblack and gas black are made by burning gas, petroleum, pitch, or some other similar substance with such a scanty supply of air that much soot is left.

Many other interesting kinds of inks are made. Perhaps the most mysterious are the secret inks. These are the inks which are used by spies, and many a thrilling story could be told of messages written with secret

inks, which have passed through an enemy's hands without being found out. Secret inks are made of substances which do not show on paper until exposed to heat or treated with some special substance or chemical. You can try a simple secret ink yourself by writing with lemon juice. When this is dry, hold the paper over a flame and see how your writing suddenly becomes visible.

A LONG JOURNEY FROM AN OCEAN BED

HAVE you ever been in Texas or in Kansas? You will find it hard to believe that these states, which look so much like the rest of the country, were once lying at the bottom of the sea. But we have good proof that millions of years ago they formed part of the bed of the ocean. And this proof is found in every schoolroom in America.

You would never guess that chalk is made of the shells or skeletons of millions of tiny sea creatures which lived thousands and thousands of years ago. Their little shells can be seen in chalk with the help of a powerful microscope. Long, long ago these little animals died and their bodies settled in the bed of the sea, becoming part of the limestone bottom.

Now you are wondering how they ever got to Texas or Kansas. This story belongs to the history of the earth which is called geology. Many wonderful things happened to the surface of the earth before it began to look as it does to-day. Even yet tremendous earthquakes occur sometimes, when the hot melted rocks and gases which are far down inside the earth suddenly move

about with great force. They cause the surface of the earth to tremble and quake violently, sometimes even to split open in enormous cracks. You have heard, too, how volcanoes are sometimes made to awaken or become active by these hot moving substances inside the earth. They shoot forth flames and throw out great rivers of melted rocks and minerals called lava. Sometime, long ago in the earth's history, some such great disturbance took place, and it was so powerful that it pushed up great parts of the bottom of the ocean so high that they became a part of the dry land. That must have been a terrifying earthquake.

It was one of those great earthquakes which brought up out of the sea a part of the ocean bed, thickly covered with masses of tiny shells. In the air and sunlight they dried and formed what we call chalk deposits. Such deposits are found in many parts of the world. Some of the largest are along the coasts of England and France. At Dover, England, they form great white cliffs which are very beautiful. When you learn that the shells of over a million little animals went to make one cubic inch of chalk you will know that countless millions of them must have died in order to form such cliffs.

Besides being cut into crayons for blackboard use, chalk, when it has been thoroughly washed and cleaned and powdered, is called whiting, and is used in tooth powders, in pastes and powders for cleaning silverware, and in putty-making. Chalk — or a substance almost the same as chalk — is used in making cement and paints and when mixed with water it forms whitewash

which is often used to give a clean white surface to plastered walls and ceilings.

Colored crayons are made by mixing chalk with a dye or coloring matter and working the materials into a paste with some sort of gum water. When it has been pressed into pieces it is then allowed to dry. Red chalk is really a kind of clay which contains a great deal of ochre, or iron oxide.

OF WHAT ARE PASTES AND GLUES MADE?

THERE are probably none of us who have not made scrapbooks with homemade pastes. We remember that we tried first a mixture of flour and water and found that the pictures did not stick very well with that. Later perhaps we learned that by cooking a thin mixture of starch and water we could make a very good paste, which would hold much better.

Since starch and flour both contain sticky substances, it is not surprising to learn that most pastes which we buy in the stores are made of a mixture of flour, starch, and gelatin or glue. Gelatin is much like glue except that more care is taken in its manufacture, so that it will be purer. You have noticed that many pastes have a pleasant odor. This comes from the fragrant oil, usually oil of cloves, which is used with alum to preserve the paste and keep it from moulding.

Paste will hold together light substances such as paper, but when something is needed to stick together articles made of leather, wood, or china some stronger material is needed. For such purposes we have glue and mucilage.

Glue is made from the hides, bones, hoofs, and horns of animals like cattle and sheep. The best glue can be made from hides but, since those are so much in demand for making leather, more glue is made from the other parts. Glue factories are generally run in connection with meat-packing houses. There the animals are killed and their meat is prepared for market, so it is a good method of saving waste to manufacture glue in the same place. The materials are first treated with a chemical which will remove the fats, and are then boiled in water until the glue oozes out. The glue settles to the bottom of the tank and is drawn off. It must then be bleached and made as clear and clean as possible by the use of chemicals. After these processes it is allowed to "set" or form a jelly-like substance. This substance is cut into pieces, dried thoroughly and made ready for the market. Such solid pieces of glue must of course be melted before being used. A liquid glue, such as we often buy in metal tubes, is made by adding some kind of acid to the solid glue. Glue is the strongest of all substances used for joining two pieces of material into one, and is therefore in demand for furniture-making.

A thin solution of glue, used to give a gloss to papers or textiles, is called "sizing."

Mucilage looks much like liquid glue, but is made of something quite different. Have you ever seen on the trunks and branches of certain kinds of trees, such as the peach and cherry, lumps of a clear, solid substance which looks like gelatin? From various kinds of trees such a jelly-like substance is collected, then cleaned, and dissolved in water, forming mucilage.

Adhesive plaster, such as is used by physicians to bind up wounds and broken bones, is made partly of rubber. You could almost have guessed this from the way the gum in the plaster will stretch. The adhesive is made of a mixture of rubber, wax, gum, pitch, and orris root. The doughy substance obtained from cooking these materials together is smeared on to the cloth by hot rollers.

Another kind of sticking bandage is called court-plaster. This is made by spreading on cloth a mixture of isinglass and glycerin.

Isinglass is a kind of glue which comes from the bladder of several kinds of fish. Russian glue is made from isinglass and is considered the finest on the market. Isinglass, when well prepared, is very pure and is used in cooking, like gelatin. It is also used for making imitation pearls.

THE QUEEN OF THE BUSINESS WORLD

FIFTY years ago the useful typewriter, without which our modern business office could not run at all, was still so new that few people were even aware of its existence. Your grandfather can no doubt remember the time when typewriters were unknown and writing of all sorts had to be done by hand. To-day there is scarcely a person in the civilized world to whom this necessary little machine is not more or less familiar.

The idea of making a machine which would write occurred first to an Englishman over two hundred years ago. He invented a crude sort of machine and had it patented, but it was never manufactured and placed

upon the market. After his time the idea kept occurring to various people here and there over the world, and several attempts were made to produce a machine which would write faster than a pen. Many of these early attempts were prompted by the desire to provide some way for blind people to write. But all these machines were awkward and slow. The best early one was invented by a man named Francis. The keys of his typewriter were like those of a piano. He planned a way of inking the type by means of a ribbon saturated with ink. This idea is still used on the modern typewriter.

The credit for inventing the first really successful machine belongs to a Wisconsin man by the name of Sholes. Three other men helped him with suggestions and improvements, and in 1871 he secured a patent for it. He found it impossible to manufacture the typewriter himself and in 1873 offered to sell his model to a gun-manufacturing firm by the name of Remington. The first Remington typewriter was made in 1874, and in that year four hundred machines were manufactured and sold.

Those early machines were far from being as perfect as our modern ones. They wrote only with capital letters and were large and awkward. In fact, the first ones were advertised as looking like family sewing machines. But they rapidly became popular, and in spite of their high price the Remington business grew rapidly. Mark Twain was one of the early purchasers. He tells us in his autobiography that *Tom Sawyer* was the first story he wrote on his machine. In 1876 the

new typewriter was exhibited at the great Centennial Exposition in Philadelphia and examples of its work were sold as souvenirs at twenty-five cents a sheet.

The modern typewriter factory is a marvelous place. When you look at a machine to-day and see its many parts, its keys, type bars, rubber roller, screws, springs, bell, metal bars, and all its complicated mechanism, you wonder how it could ever have been put together. All these various pieces are made in the "parts" factory. Many materials are used, including iron, copper, nickel, wood, leather, felt, and steel. Some of the pieces are made by casting metal in sand moulds, and other parts, including the type bars, are made by punching them out of sheets of metal by means of properly shaped "dies." In the "assembling" room the many parts are rapidly put together by workmen and each machine is then carefully inspected and tested before it is ready for the market.

By courtesy of the Remington Typewriter Company

THE FIRST COMMERCIAL TYPEWRITER

Many inventions for improving the typewriter have been made since 1874. There are now attachments for the machine which make it possible to add, subtract, and keep accounts very accurately. There are machines for writing almost all languages, even those which do not use the roman alphabet and require entirely different type bars. Many kinds of typewriters are now made, including small, light ones which can be carried about easily from place to place.

The typewriter is now a universal necessity in the business world. It saves an immense amount of time and labor, besides providing records which can be read more easily than handwriting. Every business office is equipped with typewriters for carrying on its correspondence and keeping the records and accounts. By using carbon papers it is possible to make many copies of an article or letter at a single typing and so save a great deal of time. Practically no newspaper office to-day will accept material for publication unless it is typewritten, and most publishing houses require authors to send book manuscripts in typewritten form.

The "touch" method of typewriting has been invented so that a typist can write without looking at the machine. It is possible to learn by touch where the different keys are located, just as one learns to play a piano without watching one's hands. This method has been made possible because nearly all kinds of typewriters have the "universal" keyboard; that is, the keys for the different letters of the alphabet are always located in the same places, and are so arranged that the letters most frequently used rest just below the hands

when in position for writing. By means of this touch system one can write with much greater speed. The average typist can write about sixty words a minute, which is three times as much as the ordinary person can write with a pen. Experts can type more than one hundred words a minute. The record for speed in typing is one hundred and forty-three words a minute.

PART II

THE HOUSE I LIVE IN

OUR OLDEST BUILDING MATERIALS

WHENEVER man wishes to build a house in a cool climate, to put up a tall monument, or erect a bridge over a great river, he wants to make it of the strongest material he can find. He wishes it to stand against the force of winds, storms, and rains, and to resist the effect of ice, frost, and great cold. Before man discovered how to make concrete the hardest building material he could find was stone. Stone has been used for building purposes for thousands and thousands of years — longer than anyone knows.

But the history of stone is much older than that. It is connected with the old, old story of the earth, called geology. We do not have time here to tell how the earth was formed, or how millions of years ago it was a huge ball of melted rocks and minerals. Many of the various kinds of stone which are used for building, such as granite, limestone, marble, and sandstone, were formed ages ago while this hot ball was slowly cooling off.

Granite, one of the hardest of building stones, is made of various minerals, such as quartz, feldspar, and mica, which a long time ago were melted all together in the red-hot interior of the earth. By some sort of earth-

quake or the action of some great volcano this melted substance was pushed near the earth's surface, where it

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CUTTING HUGE BLOCKS OF GRANITE IN A VERMONT QUARRY

could cool off; and as it cooled its particles grouped themselves in regular shapes or crystals, forming the beautiful granite which is used for decorative and building purposes. It may be found in various places all over

the world. Its color varies from a sparkling whitish-gray to a very dark gray and from a delicate pink to dark red. Very wonderful saws and other machines have been invented which make it possible to cut granite and to shape and polish it for almost any building purpose.

Most limestones and marbles, which are very closely related, are made chiefly of a substance called carbonate of lime and were formed millions of years ago by the skeletons of minute sea-creatures. The sea bed where they collected was sometime in the earth's history forced by an earthquake up out of its place under the water and became a part of the dry land. Some limestones were formed by centuries of deposits from hard water containing much lime. You have noticed, perhaps, how a teakettle used for hard water becomes gradually coated inside with a layer of lime. Limestone is found in many places, but the chief source of supply in the United States is in Indiana and Kentucky.

Marble is a kind of limestone whose nature has been changed at some time in the earth's history by terrific heat and pressure. It is our most beautiful building stone. In the United States most of our marble comes from Vermont, but perhaps the most beautiful in the world comes from Italy or from the Pyrenees. The lustrous white marble used by sculptors comes mostly from northern Italy. The color of marble varies greatly, sometimes being dark green, dark blue, lemon-yellow, red, black, or a wonderful mottled mixture of colors. This variety of colors depends on the additional substances which became mixed with the lime in the formation of the marble.

Sandstone, as the name shows, is made of sand, which has been transformed into solid stone by means of pressure or by some kind of natural cementing material, such as silica or iron oxide. This cement which holds the grains of sand together determines the color of the sandstone and its hardness. Some sandstones are almost as hard as granite, while others are too soft to be of much value for building purposes.

Slate is a quite different kind of stone. You know it best in the blackboards in your schoolroom, but it is also used for roofs, floors, mantels, sinks, and washtubs. Not many years ago it was employed for making the "slates" used in schoolrooms. Each child had his own thin tablet of stone and used it instead of paper. He wrote with a pencil which was also made of slate. Those stone tablets are no longer in use; it was very hard to keep them clean and sanitary. A schoolroom full of squeaking slate-pencils as they rubbed against the slates was a noisy, nerve-racking place.

Slate is made chiefly of clay. In past ages this clay was deposited by water. Later it was covered up with sand or some other substance. By means of heat and heavy pressure sometime in its history it was changed into the hard substance it now is. The peculiar thing about a block of slate is that it will split into thin layers. It is dug or quarried out of the earth in big blocks, which are then split by hammers and chisels. It is the thin sheets or layers which are used for blackboards and for building purposes.

Any kind of stone to be used for building must be taken out of its bed in the earth by means of quarrying.

This is done in various ways, depending on the kind of stone. Some stone is so formed that large cracks occur in it here and there. This makes it easy for the quarrymen to work, as they have only to split the big pieces into smaller ones and lift them out by cranes. Other very hard stones must be loosened and broken up into large blocks by the use of some explosive. Dynamite is too powerful to use for blasting building stone, as it breaks the stone into too small pieces. Various tools are used in quarries, such as drills, hammers, picks, and boring machines. Much of the drilling and cutting is now done by electric or steam-power machines. Formerly it was done entirely by hand. Some splits are made in huge stones by the "plug and feather" method. Holes are drilled in the stone in a straight line and only a few inches apart. In each hole two "feathers" are set. These are pieces of steel rounded on one side to fit the hole. Between the feathers a plug or wedge is placed. Then all the plugs are driven into the holes by hammers until the stone splits.

When blocks of stone have been lifted from the quarry by cranes they must be cut and sometimes polished by special stoneworking machinery. There are saws, planes, and lathes for stoneworking just as for woodworking, so that a piece of stone may be chiseled and carved in almost any beautiful design.

LUMBER IN THE MAKING

If you were to make a list of all the uses for wood which you could think of, you would no doubt leave out many important ones, because wood is used to-day in so many

surprising ways. You would of course think first of its value as a building material, because it is used so generally for floors, window casings, and doors, even in houses which are built of stone, brick, or concrete. Perhaps you would think of furniture next, for wood is used in furniture-making more than any other material. Then you might think of telephone poles, paving blocks, fence posts, railroad ties, and packing boxes. Perhaps you would forget smaller articles, such as pencils, matches, clothespins, and toothpicks. With all these things you would probably forget one of the most important uses for wood and that is in paper-making. It is used, too, for making a kind of artificial silk. The tannic acid which is so important in tanning leather comes from certain kinds of wood. Charcoal, a very important fuel which burns with a great deal of heat without making smoke or flame, is made from charred or partially burned wood.

Many other uses are found for wood besides these which we have named. But without waiting to think of any more you will not be surprised to learn that over a million and a half carloads of lumber are used in the United States every year. This means that thousands and thousands of beautiful trees must be cut down each year to furnish us with this necessary wood. The cutting down of a great tree, which has lifted its leaves to the wind and the sunlight for so many years, is a very sad sight. But trees reach a time when they are fully ripe and their wood is ready to serve in its many useful ways, while after this time they grow old and finally die and decay, so that their wood is of no value

whatever. If we are careful to plant new trees whenever we cut down grown ones, our beautiful forests do not suffer in the long run from so much use of lumber.

The making of lumber is one of the most important industries in the United States. It is perhaps our very oldest industry. When the first white men came to this country they found it covered with forests. The first work before them was to clear the land, so that they might have logs and lumber for building their homes and open spaces for planting and raising their crops. The earliest lumbering was done entirely by hand as there were at first no sawmills for cutting the boards. The first sawmill was established in 1633. This mill had to be located beside a stream of water, as the wheels which ran the saws were turned by water power. Later, when steam engines were invented, those were also used for running sawmills.

The cutting of the trees which are sawed into lumber forms a very important part of the lumber industry, called "logging." The lumber camps are located in sections of the country which are covered with dense forests. As several hundred men are usually employed in a single place, the camp looks like a small village. There are huts or houses where the workmen live, stores, office buildings, and a large structure where the kitchen and dining-room for the whole camp are located.

Before the cutting takes place trained woodsmen go about through the forest, marking the trees which are to be felled. A deep notch is cut on one side of each tree, showing the direction in which it should fall when cut.

The trees are cut down with big saws, which are worked by two men, one at each end. The branches are then cut off, and if the tree trunk is very long it is divided into several logs.

Various methods are used for moving huge, heavy logs from the forest to the sawmill. In the far North

By courtesy of the Southern Pine Association

WOODSMEN FELLING TREE NEAR LUMBER CAMP

the logging is carried on during the winter months. It is then easy to haul the logs over the snow to the logging road. This road is kept flooded with water each day so that it is always covered with a fresh coat of ice. Over this road the logs are hauled on sleds to a river or lake, where they are piled up to wait for the spring thaw. When the ice has melted on the river

the logs are floated down to a sawmill, located on the bank of the river or lake.

From mountain camps the logs are often sent down the mountain-side in wooden chutes or slides which are specially built for them. Sometimes a dashing

By courtesy of the Southern Pine Association

CRANE LOADING LOGS FOR SHIPMENT TO THE MILL

mountain stream is enclosed in a wooden chute and is used for carrying the logs down to the river in the valley.

In the camps of the South and the Northwest, special railroads are used for carrying the logs. All through the forest where the logs are being cut temporary railroad tracks are built, which can be easily torn up when the camp moves. Great machines called "skidders,"

which run on caterpillar wheels, such as were seen on the tanks in the World War, are used for loading logs on the flat railroad cars. These skidders are furnished with great chains and hooks which drag the logs to the cars. Strong cranes then lift the logs and place them securely on the cars to be carried to the sawmill.

By courtesy of the Southern Pine Association

LOGS IN THE LOG POND AT THE MILL

At the mill the logs are kept in a mill pond until ready to be sawed. This keeps the wood fresh and green and prevents it from rotting and from being injured by insects. From the pond a wooden chute leads to the mill. Along this chute runs a big chain provided with spikes. The logs are directed into the chute and by means of the chain are carried up to the mill. Here

they are washed with hot water and then sawed into boards by powerful machines fitted with huge sharp saws. Such rough lumber, before it can be used for finer purposes, must go to the planing machines which smooth the surfaces.

Lumber must be dried before it can be used. When a tree is cut it contains a great deal of moisture and the logs of course absorb much more during the journey down the river and the bath in the mill pond. Unless lumber is carefully dried it will warp, that is, become bent and twisted. It may be dried in the open air, where it is stacked in the lumber yards in such a way that air spaces are between all the boards. It may also be dried in a steam kiln or oven. This is a more rapid process but requires much more care.

In cutting and sawing logs a great deal of material was once wasted. The bark-covered slabs which are taken from the outside of the logs and the piles of sawdust which fall from the saws look practically useless. But no modern factory of any kind allows waste if it can be helped. The slabs are now used for making shingles, laths, and other small kinds of lumber. Quantities of sawdust are used for making wood alcohol and wood pulp for paper-making. A great deal of "waste" is often used for fuel in running the sawmill machinery.

Some kinds of trees are of little value for lumber. The soft woods, such as pine and spruce, are used chiefly for building purposes. The hard woods, like maple, oak, birch, and hickory, are used for furniture-making. Some of the most valuable woods used in furniture-

making, such as rosewood, mahogany, and ebony, grow in tropical countries and are imported into the United States.

Since our country was settled by white men more than half of its forests have been destroyed. It is said that if we go on using our timber as rapidly as we have done in the past we shall have no forests left in another hundred years. For this reason we are beginning to realize how important it is to plant new trees all the time. The United States Government now has foresters who try to protect our forests from fire and from wasteful use, and to teach us how important it is to plant new trees when we cut down old ones.

MAKING BRICKS WITHOUT STRAW

BRICKS are among our most common building materials and have been used for the construction of houses since the time of the ancient Babylonians and Egyptians. Those early peoples made their bricks of clay or mud and dried them in the sun. In Egypt the mud from the banks of the Nile River was used a great deal. This had to be mixed with straw to prevent the bricks from cracking. In Babylonia and Assyria the bricks were less often made with straw, as rains in those countries were so rare that the sun-dried clay held up very well.

Our modern bricks are made by a much more efficient process. We have learned to produce them without straw and without sun-drying, and can make them so strong and hard that they last almost as well as stone.

Bricks to-day are still made of clays or shales — natural earths which are the product of the age-long

decay of certain kinds of rocks. Clays are rich in silica and alumina, which make them easily moulded when wet. They are of varying colors, depending on the presence of other materials such as lime, iron oxide, or chalk. Red clays, for instance, contain a high percentage of iron oxide.

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A MOULD FOR SHAPING BRICKS

All bricks must pass through four distinct processes in their manufacture: mixing, moulding, drying, and burning. These processes vary with the kind of brick desired, but the principle is always the same. The first step is the mixing of the clay or ground shale with water. The amount of water used depends on the kind of moulding process through which the clay is to pass. The dry-press process requires a small amount of water, as the clay is poured into the steel moulds of a powerful press and shaped into firm, hard bricks by compression. The hand-moulding process is less used now than formerly but produces a high grade of bricks. For this

process the paste must be soft, as hand pressure is much lower than machine pressure. A mould the size and shape of the brick is used. It is dipped into water and the clay or paste is pressed into and shaped to the mould by hand. A third process of moulding, that most generally used, is the wire-cutting or stiff-mud process. For this the wet clay is poured into a mill which squeezes out a thick ribbon or band of clay paste the exact height and width of the bricks desired. This ribbon is then divided into bricks of correct length by means of wires stretched on a frame.

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CAR WHEELING DRIED BRICKS FROM HEATED STEEL TUNNELS

The third step in brickmaking is the drying. This is done either in the open air or by artificial heat. For the latter process the bricks are placed in a so-called tunnel-dryer, which consists of a long chamber in which the bricks are placed on cars and dried by steam heat or warm gases.

The burning or firing of the bricks is the final step, which makes them hard and waterproof. The bricks are placed in a kiln or furnace where they are baked at a very high temperature, the degree of heat used depending on the purpose for which the brick is intended. Face bricks are burned at a temperature of from 1200° to 1300° centigrade, while kilns for common building-

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STACKING BRICKS IN KILN FOR BAKING

bricks are usually not heated above 1050° centigrade. Bricks which are to be used for lining the inside of furnaces are burned at a very much higher temperature.

In the southwestern United States so-called "adobe" bricks are used. These are much like the old sun-dried bricks of the Babylonians. Some adobe houses still standing in Arizona and New Mexico were built centuries ago by the Indians and Mexicans. This proves that they really are very strong and durable, but they can be used only in a warm and dry country.

THE KING OF METALS

Iron, cold iron, is master of them all,
In war and in peace.

MANY and perhaps most of the marvelous things which men have made to meet the needs of life are due to the use of iron and its younger brother, steel. Without them we should face the weather, the beasts of the

forest, and the hardships of finding food and shelter quite like the men of the Stone Age and the Bronze Age, who lived in caves and used implements of wood, stone, and copper. Those early men did not dream that some of the red, yellow, or black earth upon which they stood contained the most useful metal in all the history of the world — iron, more important and wonderful than any of the so-called wonders of the world.

Almost everything we touch and use in our everyday life is fashioned from or by means of iron in some form. To iron we owe the furnace and its tools, the kitchen stove and its pots and pans, the pipes carrying both water and gas, the fixtures for light. Even the wood, cement, brick, and stone of our homes are shaped by tools made from iron. Our great bridges and sky-scrapers, towers and tunnels, are framed in steel. We travel by car, train, or ship, build factories and make machinery, pump water and gas, weave garments and prepare food; all these we do through the countless uses of iron and steel.

Iron is the king of metals. It is not the oldest, yet it is one of the early discoveries. It is found in most of the civilized countries of the world, being one of the most common of the substances forming the earth's surface. Like aluminum, iron is hidden among other elements and cannot be found alone in pure metal form. It combines with many different kinds of things — it is found in rocks, in soil, and even in plant and animal organisms.

Long ages before iron was known the primitive men made their weapons and tools of copper, forming their

useful implements by pounding the soft metal upon stone. Many fine examples of their art may be seen in museums to this day. Then, so the story goes, long years passed by, and one fortunate man made a huge fire in a high wind, using by accident both charcoal and rich iron ore. In the hot coals he discovered a lump of strange metal which he easily shaped, while warm, into a spear-head, far superior in hardness and sharpness to any known before. Thus seemingly iron appeared by magic, and those who forged the great swords of King Arthur and Roland were looked upon with awe and reverence.

In many countries where rich ore was found this mysterious art of burning iron out of rock and soil was slowly spread and developed by the Assyrians, Egyptians, Chinese, and others. Many centuries later, when the Romans conquered Britain (England), they were surprised to find the Britons making iron in rough, crude furnaces.

Perhaps you have noticed how ordinary iron will rust when exposed to air and moisture. That is one of its peculiarities. Iron insists on living, if possible, in chemical combination with oxygen, a gas which we know is a part of both air and water. This rust, an oxide of iron, is somewhat like iron ore. When great heat, much air, and large quantities of carbon (in charcoal or coke) are applied to iron ore, the metal is separated from the oxygen and other friendly elements. The amount of carbon and the kind of furnace used determine the kind of iron produced. The sort with the least amount of carbon is "wrought iron." While

hot it is soft and easily shaped. Less than five hundred years ago the secret of making "cast iron" was discovered, the metal coming from the furnace in liquid form and, when poured into moulds, hardening into any desired form. The thick, brittle metal of your kitchen

UNLOADING IRON ORE, LAKE ERIE
From *The ABC of Iron and Steel*, by A. O. Backert, by courtesy of the Penton Publishing Company

range is probably cast iron, and so also are the doors on your heating furnace.

Iron appears in so many odd forms that it seems more mysterious than any other metal we know. It may be as hard as a diamond or as soft as copper, as brittle as glass or as malleable as silver. It may join or weld when heated, melt with ease, carry both heat and electricity, or stubbornly refuse to do any of these

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MOLTEN METAL RUNNING INTO MOULDS FROM BLAST FURNACE

things. Most of the peculiarities of iron have been developed into great uses by important inventions within the past two hundred years. Chief among these

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"PIGS" BEING REMOVED FROM MOULDS

is the famous Bessemer process of producing steel in large quantities, suitable for general purposes in the construction of buildings, railroads, ships, and bridges.

Steel, like cast iron and wrought iron, is a product of iron ore, determined by the amount of carbon burned out of the ore. Steel now appears in a great variety of forms. It may be soft or brittle, tough and strong, or

pliable as lead. It may be made into delicate instruments used by surgeons or into mighty torpedoes and cannon of war; the pens and scissors in your home or the miles of wire fence along the countryside.

The United States now holds the world's leadership in the iron industry, shipping iron and steel products to all parts of the globe. The ore is mined in many of our states but the largest mines known are located in Minnesota in the famous Mesabi district near Lake Superior. By cheap water and rail transportation this ore is carried from Duluth to the enormous steel mills at Gary, Pittsburgh, and elsewhere. Here are great tower-like blast-furnaces which melt the iron from the ore, enormous open-hearth furnaces with molten steel running into huge ladles or buckets, long cranes or arms of steel pouring fiery liquid metal into moulds, strange moving belts carrying smaller moulds of bubbling fire which cool into solid chunks of metal called "pig iron," and a thousand other wonders, unknown at the famous forge of Vulcan in the heart of the mountain, where the dread thunderbolts of Jupiter were said to be made.

THE NEW STONE AGE

It is not surprising that primitive man soon learned to use stone for making tools and weapons, and a little later in his history even to build great monuments, tombs, and temples of stone. Of all the materials which he could find stone was the hardest and lasted the longest. The period in man's civilization when all his tools and weapons were made of stone is called the

Stone Age. One of the wonders of modern civilization is the discovery by man that he can make an artificial stone which is even harder and more durable than most natural rocks. During the last thirty-five years the use of such man-made stone has so increased that our twentieth century is sometimes called the "New Stone Age."

The beginning of this new age really dates from the year 1824. An Englishman then discovered that by burning limestone and clay together he obtained a material which, when ground to a powder and mixed with water, would "set" or harden into a rock-like substance, even when covered with water. He named his material "Portland cement," because the stone-like substance which it made resembled the building stone found in quarries at Portland, England.

The making of cements did not begin in 1824. The old Romans had learned to make a very hard cement from volcanic ashes and lime. This was also an "hydraulic" cement, that is, one which would harden under water. Hydraulic cements are very important for building purposes, as they can be used for making bridges and piers which must be partly under water all the time. The Romans used this cement a great deal in building. The great aqueducts which carried water many miles from the mountains to Rome were made of this cement combined with stone. But for hundreds of years after the time of the Romans the secret of making such cement was lost, and it was not until the nineteenth century that it was discovered again.

Many millions of barrels of Portland cement are now made in the United States each year. Nearly every

state in the union has quarries which produce some kind of limestone suitable for cement-making. Careful study has shown just how much of certain materials should be used to make the best cement, and the limestone, clay, and all other materials needed are carefully measured. The materials are crushed and ground to a powder and are then ready for the burning. This takes place in a kind of oven or kiln which whirls round and round very rapidly. The powdered mixture is run into the kiln at one end and burning coal-dust is forced in at the other. The powder melts under the action of the coal-dust flames and forms lumps about the size of peas. These run from the kiln and are heaped in piles to cool. They are then ground again to powder, which is the dry Portland cement.

Concrete, which is even harder than Portland cement, is made by mixing some kind of hydraulic cement (usually Portland) with sand, water, and crushed stone or pebbles. When this material sets it is harder than most stone, and if properly made will last longer than stone. Concrete is used nowadays in most of our large buildings, and is employed all over the world for great engineering works such as the building of dams, bridges, tunnels, roads, and even ships. The great locks and dams of the Panama Canal were built of concrete. When man discovered a way of rëenforcing concrete, that is, making it stronger by putting bars or strips of metal inside, he had then a building material which was remarkable for its strength.

Concrete is usually mixed in machines on the spot where the building is done. It is carried from the mixer

in wheelbarrows, cars, or buckets operated by derricks to the point where it is wanted. Wooden moulds or

By courtesy of the Portland Cement Association

REËNFORCED CONCRETE DAM HOLDING MOUNTAIN WATER FOR SAN FRANCISCO

forms are usually built in the shape of the pillar, wall, floor, or other part, and the concrete is poured into the forms. If reënforced concrete is desired, the steel bars are placed inside the forms before the concrete is poured in. After the concrete has hardened the wooden forms

are taken apart and the concrete is ready to stand for a long time.

It is possible, by special treatment, to imitate natural stones with concrete. It is sometimes hard to tell one of these imitations from real stone. Concrete is often made into blocks by the use of small wooden forms. These blocks are used for building small houses, verandas, fences, and fence posts. They are not suitable for great office-buildings, bridges, and dams, because they are not so strong as solid reënforced concrete.

Another modern way of using Portland cement or concrete is to mix it with lime, water, and sand to form stucco. Stucco is used for the outside of many small houses to-day, as it is fairly durable and can be made to look very artistic. The wall is first covered with metal or wooden strips called lathing, and the stucco is laid over this surface. Many artistic effects can be obtained by patting the wet stucco with brooms or trowels or by dashing over it a layer of fine sand or little pebbles.

Plaster, which is often used for covering the inside walls of buildings, is much like stucco. Stucco itself may be used for plastering, though real plaster is usually made of lime or plaster of Paris mixed with water. The plaster is generally put on in three coats to make it strong and durable. The first coat is mixed with hair or some kind of fibre so that it will hold together well.

THE MYSTERY OF MELTED SAND

Because the glass used in our windows is placed there to be looked through rather than looked at, we think little about it. But glassmaking is an extremely deli-

cate process and requires a great deal of skill. You would never guess what glass is made of. The principal material which goes into its make-up is sand, a very fine quartz sand. The finer the grade of glass desired, the finer the sand must be; so for the finest grades pure quartz is often crushed very fine and run through a screen.

The art of making glass has been known a long time, so long that the story of its beginning is legendary. At an early date in the history of Venice the Venetians had learned to make such beautiful glass that it became famous the world over. During the Middle Ages the glassmakers of Europe knew how to make the beautiful stained glass which went into the windows of their cathedrals. No one knows exactly how that stained glass was made, and modern manufacturers have never been able to make any quite so beautiful.

Besides sand, the substances necessary for the making of glass are soda and lime. These must all be very clean, as a little impurity will spoil the whole mixture. These ingredients are placed, along with a certain amount of "cullet" or broken glass, in huge fire-clay crucibles or tanks, which hold two hundred or more tons of material. There they are boiled at a temperature of 2500° to 3000°, making a combination that looks like water when the materials are thoroughly melted and mixed. Impurities collect at the top and are skimmed off while the mixture is still boiling.

When the liquid has cooled enough to be somewhat thick and sticky, the interesting part begins. The glass mixture must now be blown, very much as one

blows soap bubbles. Until recently all glass was blown by men known as glass blowers, but machinery is more and more taking the place of men in this industry. In the making of ordinary windowpanes the glass blower has a long pipe, very much larger and longer than a

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BLOWING GLASS TUBES FOR WINDOWPANES

soap-bubble pipe. This he dips into the hot mixture and he blows through it with great force until he has formed quite a long cylinder, swinging it back and forth in a long pit or swing-hole as he blows. The cylinder is then placed on a table and the ends are cut off by means of a hot glass thread. The cylinder is split open by drawing a line down one side with a hot iron,

the line being immediately touched with a cold iron, so that the cylinder splits from the sudden change in temperature. It is then reheated enough for it to be flattened and smoothed, when it is ready to be cut into window panes.

Plate glass for windows is made by a different process, in which the glass blower has no part. When the hot glass mixture is quite ready, the crucibles are lifted by big electric cranes, which carry them to steel tables on which their contents are emptied. Huge steel rollers iron out the hot mixture to a thickness of about half an inch. The glass is then annealed or toughened by a very slow heating and cooling process. The sheets are passed slowly through a long heated tunnel which gradually becomes cooler, until at the end of five hours the glass is thoroughly toughened. The smooth shining surface is obtained by a careful grinding process. Large mechanical runners or feet grind the sheets with fine sand until all roughness and unevenness are worn away. After this the surfaces are polished with felt runners and fine emery or powdered iron-oxide until they have a beautiful lustre. Sheets of plate glass may be cut with diamond points, as diamonds are even harder than glass.

Colored glass is made in the same way as clear glass, except that small amounts of metal oxides are added to the mixture when it is boiled. Cobalt will make blue glass, manganese makes pink or purple glass, red and black shades are made by using copper, and some of the most beautiful shades of red are obtained by adding a little gold to the mixture.

PRESERVING OUR HOUSES

You have always thought, no doubt, that we paint our houses in order to make them attractive; that the white enamel paint in our bathrooms is put there solely to match the white tiles; and that our furniture is stained and varnished so that it will be more artistic in our homes. But this is only one of the minor purposes of paint. If it were not for paint our wooden houses would soon decay and fall to pieces, our furniture would speedily wear out, and even the iron framework of our large buildings would rust and waste away under the influence of the rain and weather.

All paints are composed of a liquid, called the "vehicle," and a coloring matter, called the "pigment." Usually a thinner is added to dilute the paint to the proper consistency and a drier is used to ensure its speedy and thorough drying when spread on a surface.

In oil paints, which are most used, the best vehicle is linseed oil, made from crushed flaxseed. This oil dries with a hard, waterproof surface and hence is very good for paints which are to be exposed to the weather. But linseed oil is expensive and is therefore often diluted with some other harmless oil, such as soy-bean oil. Poppy-seed oil is a very good vehicle, but is too expensive for use in common house-paints.

With the linseed oil is mixed white lead, which is a white pigment. If the paint is to be colored, the proper coloring matter is also added. These coloring pigments may be mineral matter, various kinds of earths, or arti-

ficial dyes made from coal tar. For black either lampblack, boneblack, or graphite, a mineral form of carbon, is used. Turpentine is generally used as a thinner because it evaporates quickly. The paint is thinned with this so that it may be spread easily with a brush. Turpentine is expensive, however, so benzine is often used, although inferior to turpentine. As driers, such substances as red lead, sugar of lead, and sulphate of zinc are used.

Most paints are now made by machinery. The ingredients, consisting of the white lead, the linseed oil, and the coloring matter, are dumped into a mixer, where they are thoroughly stirred for hours. They are then passed to the grinder, which is made of two huge grindstones set close together and revolving in opposite directions. The mixture is ground until it is very fine and smooth. The necessary thinner and drier are then added and, if the paint is to have the glossy finish of enamel paints, varnish is also added. The paint is then poured into cans and is ready for sale.

Paint-making sounds simple but as a matter of fact it requires a great deal of skill. Every large paint-manufacturing company has its staff of chemists who experiment continually on new recipes and new ingredients, and who test the paints constantly as they are made, ensuring the proper color and consistency. Paints which seem a great deal alike vary considerably, depending on whether they are to be used outdoors, on heated surfaces, on wood, metal, or concrete, and whether they are to have a glossy finish or a dull, flat finish. One large company manufac-

tures paints from over five thousand different recipes or formulas.

Some paints are made with water instead of oil as a vehicle, and are called water paints. Calcimine is a water paint. It is made by mixing slacked lime or whiting and the color pigment with water. Glue or casein is added to make the paint stick to a surface. These paints are not waterproof and hence cannot be washed or used outdoors.

MAKING VARNISH FROM GUM

VARNISH is the transparent liquid generally used as a finish for furniture. It produces a bright and durable lustre, but does not hide the grain of the wood. It is a thick, sticky fluid, made from resin or gum mixed with linseed oil or some other non-evaporating oil.

The gums or resins used in making varnish are of various kinds and often come from a great distance. Ordinary pine resin is used in some varnishes, but this makes a poor and cheap grade which becomes sticky when exposed to heat. The best gums come from New Zealand and Africa where they are dug from the ground. These hard, durable gums are masses of the hardened sap of trees that lived thousands of years ago. This sap has been lying in the ground no one knows how long, perhaps having melted and flowed into the earth when the forests were burned ages ago. Many of the natives in the regions where the gums are to be found make their living by digging the product from the earth. They find some pieces as large as a man's head, but this is unusual. The pieces are generally small, so that the

gum-gatherers find their method of earning a living a tedious and slow one.

The process of varnish-making requires a great deal of skill. The oil and the gum are placed in separate kettles and are heated over open fires. When the correct temperature has been reached they are mixed together, and are then cooked for hours over a very hot fire. When the mixture has cooled somewhat the "thinner" or turpentine is added, in just the proper amount to obtain the right degree of thinness. For some kinds of varnish a chemical such as red lead or zinc oxide is added, to make the liquid dry more quickly when it is applied.

After the ingredients are thoroughly mixed the liquid is run through a large "filter press," where the varnish is forced to pass through hundreds of sheets of filter paper which look somewhat like blotting paper. This strains and cleans the liquid thoroughly, and it is then ready for storage. It is placed in large tanks, where it is kept at an even temperature for several months in order to "age." Varnish improves with age, so the best grades are kept for two years or more. It is finally poured into cans and is ready for the market.

Some varnishes contain practically no oil and are called "spirit" varnishes, because they are made with some liquid such as turpentine or alcohol, which evaporates very rapidly. Those varnishes dry quickly and are very glossy, but they are brittle and crack easily. For this reason they are not satisfactory to use as the finishing coat for furniture.

WALL-PAPER DESIGNS

In olden times the great nobles and barons covered the walls of their castles with beautiful cloth tapestries, which added greatly to the warmth as well as the beauty of their dwellings. The paper coverings which we use on our walls to-day are direct descendants of those beautiful old tapestries, and some of them are so beautiful that an old baron might heartily admire them.

Wall papers at the present time are made entirely by machinery, and the complex printing machines are fascinating to watch. The paper on which the design is to be printed comes in a long strip from a big roll, and passes around a huge drum which is the largest part of the printing machine. Around this drum is a series of rollers, each carrying a different part of the design cut out of metal and each printing with a different color. These rollers are so arranged that as the paper passes around the revolving drum they press in turn against the paper, so that when the paper has finished the ride on the drum the complete design is printed on it.

The necessary colors are carried up to the rollers on moving cloth belts, from pans underneath the machine that contain the color supplies. Most of the colors are made of fine white clays colored with harmless dyes and mixed with an adhesive substance until they are about as thick as cream.

After the printing process, the paper is carried from the machine on a wide cloth belt, at the end of which it is mechanically picked up by rods which pass under the

paper and carried on chains to the ceiling. From here it hangs suspended in huge loops and passes on a moving apparatus down the drying-room. The air in this room is heated so that the paper dries quickly. It is then wound on rolls which are made up into bundles of fifty and wrapped ready for market.

The preparation of the design which is used on the printing rollers is an interesting process. This is made by an artist or designer who usually makes a water-color drawing of the pattern. The pattern is then transferred to the wooden rollers and this requires a great deal of care. Workmen draw the design on the surface of the rollers, then cut and fit small strips of brass to match this design. The strips are driven into the roller and serve the part of type in ordinary printing machines. Some papers are printed from copper rollers on which the design has been engraved by hand. This is of course a much more delicate process, and it makes papers so printed much more expensive.

Before the pattern is printed the paper is usually given a plain foundation color, which is applied by large machine-operated brushes. Some papers, after being printed, are given a coat of varnish, so that they may be washed if necessary. These are excellent for bathrooms and kitchens, as they can be easily kept clean. Other papers are finished by being passed through an embossing machine, which gives them a finish resembling linen or leather. Papers which have a gold finish have been sent through a bronzing machine, which applies gilding to the design.

SPINNING METAL THREADS

HAS it ever occurred to you that the network of telephone wires which you see over the main streets of a large city looks like an enormous spider web? Perhaps these wires, which really are threads made of metal, make us think of the spider's web because they too are made by spinning.

Wires are made in many different sizes and from many kinds of metal. However, steel and copper are used most of all, since the metal must not be brittle for fear it will break while being shaped. It must be ductile, that is, capable of being drawn out like taffy, without breaking. Gold is more ductile than any other metal, but it is little used for making wire because it is so expensive. Other metals ductile enough for wire-making are nickel, platinum, silver, iron, and aluminum.

The spinning of wire is called drawing and is done in a wire-drawing machine. The metal for making wire is received at the wire factory in square sticks called billets. Steel billets are four inches square and thirty-six inches long. These are heated in a furnace to make them soft and are passed through a rolling machine which stretches them out, making them much thinner and a great deal longer. The pieces are then called rods.

The rods are cleaned first in a bath of acid, then of lime. They are then placed in ovens until thoroughly dry. After these processes they are ready for the wire-drawing machine. This machine is provided with a hard steel plate which is filled with small, cone-shaped

holes, each one smaller than the one before. A point is made on one of the rods and it is passed through the largest of these holes. On the other side it is seized by a pair of pincers which pull or draw it out and pass it around a revolving drum or spool. This drum pulls the rod (or "wire" as it now is called) completely through the hole. It is then sent through a slightly smaller hole, this time being drawn a little smaller than before. This process is continued, the wire being drawn each time through a smaller hole, until it is of the desired size. It frequently becomes too brittle to be worked and between the drawings must be sent to an oven to be heated slowly and then cooled. This process is called annealing. It toughens the wire and takes out the brittleness. Some wires are drawn twenty or thirty times to make them small enough. The very finest wires, which are to be used for the most delicate purposes, are drawn through holes cut in a diamond or ruby, two of our hardest stones. Some wires are so small that they are only one twelfth as large as the hair on your head.

Wire has been in use for many centuries, but not until the fourteenth century was it made by drawing. Before that time metal was beaten into thin sheets, and those were cut into strips. The strips were then hammered by hand into round wires by a slow, tedious process. Wire made in that manner could not be produced in large quantities and was apt not to be of even size throughout its length.

Wire is used in hundreds of ways to-day. It is made into fine netting and used for screens. The coarse

netting used inside panes of glass or walls of concrete to make them stronger is made of wire. You have no doubt seen miles of wire fences used by the farmers to separate their fields. Wire is used for making bed mattresses and springs. Very fine wires are used for watch springs and for delicate parts of telescopes and other fine instruments needed by scientists. Wire is used for making nails, needles, pins, and hairpins. Without wire we could have no telephones, wireless stations, aeroplanes, elevators, or thousands of machines which are used in manufacturing. Wire is often covered with rubber, silk, cotton, or some other material through which electricity cannot escape, and then it serves for carrying an electric current to our homes and to all the hundreds of places where it is needed. Wire protected in that way is said to be "insulated." Barbed wire, used for fences, is produced by a special kind of machine which cuts two wires into short pieces, sharpened at each end, and wraps them at regular distances about two other long, continuous wires.

Wire ropes or cables are made by twisting several wires together in order to increase the strength. Wire cables are much stronger than hemp ropes and can be used in hundreds of ways where rope would be unsafe. Almost no kind of engineering can be carried on to-day without wire cables. They are used for lifting and carrying the great cranes which are so necessary in building and in many mills and factories. Coal-mining, quarrying, and oil-well drilling would be impossible without wire ropes to carry and lift the great loads. Inclined railways, on which the cars are held in safety

by strong cables, could not exist without them. We should have no great strong elevators without the enormous wire ropes on which their loads are carried. Indeed, when we think of all the uses made of wire, it seems as if, without it, the world would have to stop working.

A THOUSAND NAILS PER MINUTE

SUPPOSE all the nails which went into the building of your house had been made by hand! Can you imagine how long a time it would have required, or how expensive the nails would have been? In Colonial times every nail had to be hammered out by hand on an anvil. Many homes had their own small forges, and even the children joined in the sport of nail-making. Nails were scarce and costly in those days.

To-day most nails are made by machinery, the whole process taking place in a single machine. Soft steel in the form of wire is fed into the machine at one end, and at the other end the nails come pouring out at the rate of one hundred to one thousand per minute, depending on the size of the nail.

Inside the machine a very interesting process goes on. The wire is gripped firmly in a "straightening carriage," which straightens the wire and carries it forward to a point where it is struck a terrific blow on one end by a hammer. This forms the head. As the hammer recedes, the carriage moves forward the length of the nail; the wire is again gripped, and powerful nippers cut the wire, forming the point of the nail at the same time, and leaving enough wire outside the

grippers to form the head of the next nail. In advancing again to make the head, the hammer operates an "ejector," which takes the finished nail from the machine. The whole nail is made in a fraction of a second.

Besides wire nails there are also wrought-iron nails, which are made from a fine grade of iron and are hand-forged. Most horseshoe nails are made in this way, as they must be even tougher than ordinary nails; otherwise they might break off inside a horse's hoof and cause a painful lameness.

The first nail-making machine was invented in 1786. So-called "cut nails" are still made to-day, but they are produced in much smaller quantities than wire nails. By the older process strips of metal of the required breadth and thickness are heated and fed into the machine. A slicer cuts off the nail in the proper length, and the cut-off piece is caught and held until a hammer strikes the upper end to form the head. The body of this nail is square — not round like that of a wire nail.

A new method of packing nails has recently been invented. By the old method the nail-making machine dropped the nails helter-skelter into a keg or box. That wasted a great deal of space and the nails were hard to take out. The new method arranges them lengthwise, side by side in a box. The packing machine is electric and exercises magnetism in arranging the nails. It operates on the principle that long-shaped iron articles, when moved by a magnet, will take a position parallel to the magnet. A shaking device drops the nails into this machine, where they take the parallel

position while falling. They are then passed into a tray which empties them neatly into boxes.

Nails vary in size from those little larger than a pin to those several inches in length, and they may be anywhere from one fortieth to one fourth of an inch in thickness.

Nails may be made of iron, brass, copper, or zinc, but most of them are of steel. Tacks and common screws are made by processes similar to those used for nails.

The first iron screws had large, blunt ends, and before a carpenter could set one in place he had to use a gimlet to begin boring the necessary hole. Then a clever machinist tried making the tip of the screw itself into a small gimlet, and the carpenter's task became much more easy and simple.

THE MIRACLE OF LIGHT

A SPLINTER of pine soaked in bear's grease made for the primitive man a fairly good light without much smoke. A shell or skull of a small animal filled with grease and a wick made of the fibres of dry plants was probably welcomed as a great invention in those early days.

The ancient Egyptians made oil lamps of rude earthenware and these were used as a source of light. Pictures of such grease-burning lamps have been found painted on the walls of the tombs of the mighty Pharaohs. Moses, Saint Paul, and Julius Cæsar may have written their great documents by the light of similar flickering lamps. And even in Shakespeare's time the public

halls were furnished with burning "rushlights" made of the pith of peeled marsh-rush soaked in fats or waxes. Travelers say that the peasants of some countries still light their homes by the same kind of rushlights, blazing and dripping from wall sockets.

The brave seagoing Phœnicians made the first wax candles of bee honeycomb and wax berries, and for several centuries candles of tallow or of wax from whale fat gave the world its best sources of light. In the great halls of grand palaces these candles were hung overhead in groups on chandeliers or candle-bearers, a name for lighting fixtures which we use to this day. When President George Washington was given a magnificent reception in Philadelphia over two thousand candles were used to light the hall.

For nearly a hundred and fifty years before our century many men interested in chemistry and physics made great improvements in tallow candles, whale-oil lamps, lanterns, and kerosene lamps with glass chimneys. Then followed a new, powerful, awe-inspiring means of lighting, the burning-vapor or gas, which made all preceding forms of illumination seem old-fashioned, dim, and inconvenient. But gas soon suffered an eclipse by a still more marvelous power. Now by the magic touch of a button we can flood a room, a house, an entire city with sufficient light to dispel darkness and turn night into day, through the everyday miracle of electricity. What wizard of man brought this about? Many men discovered and invented much before him, but to Thomas A. Edison are we forever indebted for the first practical form of

the incandescent lamp now so commonly used in our homes.

Edison, as a train-boy on a railroad in Michigan, first began his chemistry experiments in one end of a smoking-car. When one day his work set the car afire he lost his job, and then he became a telegraph operator. In the meantime the electric arc-lamp had been invented and put into use for street and factory lighting. The arc light was made by an electric current passing through two carbon rods with their ends held near together, the current jumping across this space in a bluish "arc," heating the ends of the carbons and giving a dazzling light. Perhaps you can observe this form of brilliant lighting on a near-by street-corner light, on the headlight of a railroad engine, or in a moving-picture machine.

But those lights were too large, brilliant, and expensive in cost for home use. Edison decided that he would solve the problem and with money received from an earlier invention he established a laboratory and factory in New Jersey. There he worked long and hard and spent many thousands of dollars in trying to find the right materials, testing hundreds of different kinds of plant fibres from all parts of the world for the best sort of carbon, experimenting with methods of removing air from the bulbs and creating a sufficient steady current of electricity. In the end he produced the famous "hairpin in a bottle," as his carbon incandescent lamp was called in 1879. "Incandescent" means white or glowing with heat. Carbon burns readily and is consumed in the air, as we know from observing a burning

match or a coal fire. Edison's invention removed the air from around the carbon filament or wire inside the bulb. This permitted the filament to become white hot from the electric current without being burned up. Later fine wires of the rare tungsten metal were used in place of carbon filaments, requiring much less current and giving much greater light.

New improvements are constantly being discovered and invented. The end is not in sight. Perhaps sometime through other boy inventors we shall have light without heat, similar to the wonder light of the glow-worm. Who knows?

PART III

IN THE KITCHEN

THE OLDEST METALS

BEFORE man discovered how to use metals all his tools and weapons had to be made of stone and wood. You have probably seen Indian arrowheads and hatchets made of stone, and can easily imagine how clumsily primitive men had to work in order to cut down trees or plow the soil with their rude implements.

The discovery of metal was a very important step in civilization. It was much easier to hammer implements out of metal than to chip and grind stone into the proper shapes. It was possible to make much better tools, and the invention of new things no doubt came more rapidly.

In this great advance made by primitive man copper played an important part, for it was probably the first metal which he learned to use. A chief source of copper in the ancient world was on the island of Cyprus. The ore in which the copper was found was generally burned with charcoal in a shallow pit dug in the ground. The metal would melt and fall to the bottom of the pit, forming a rough cake when it was cold. As copper is comparatively soft, this cake could easily be hammered into the shape of weapons, tools, household utensils, and other useful objects.

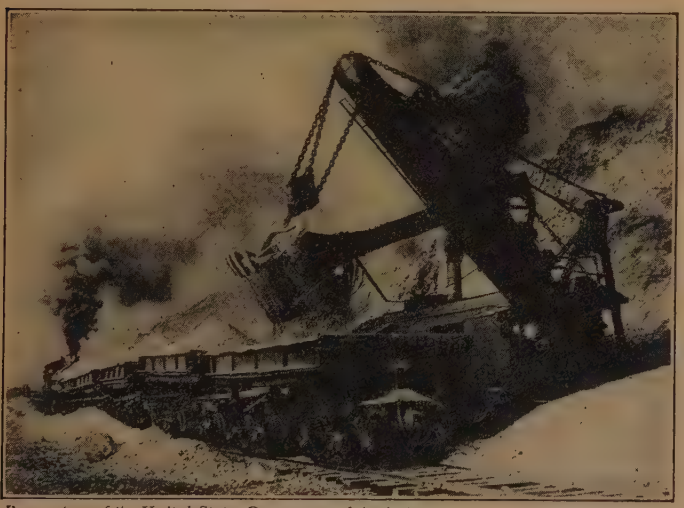
A little later man learned to make bronze by melting copper and tin together to form an "alloy" or mixed metal. This discovery may have been accidental, as it is possible that an ore containing copper also included some tin. At any rate the important fact was learned that the two metals when mixed together formed a much harder substance than either one alone. The harder a metal is, the greater its value for making tools and weapons. Bronze became so important a metal that man passed through a period in his civilization now known as the Bronze Age, when all his best implements and utensils were made of this metal. As bronze and copper do not rust or crumble away like iron, many articles made thousands of years ago by primitive men have been found in caves and excavations and are now preserved in museums.

Bronze became later a popular material for artists, and many beautiful pieces of bronze sculpture and artistic ornament have been found. In the ruins of Pompeii and Herculaneum were buried lovely examples of the bronze work done by Roman artists.

Brass, which is an alloy or mixture of copper and zinc, was probably not made until much later. A material called "brass" is frequently mentioned in the Old Testament and in other works of early writers, but probably the metal referred to was actually bronze.

Copper and its two important alloys are of great importance in the world to-day. Next to iron and steel, they are used more than any other metals. Copper will conduct or carry electricity better than any other metal known, hence it finds its chief use in the making

of electric wires. It is said that in the United States alone there are over twenty-two million miles of copper wire used for carrying the electric currents which light our homes, run our street cars, make possible our



By courtesy of the United States Department of Agriculture

LOADING COPPER ORE AT A MINE IN NEW MEXICO

telephone and telegraph systems, and in hundreds of other ways add to our comfort.

Bronze is used for making bells and cannon, for making statues, large or small, and a great many small objects valued for beauty as well as use. Brass enters into the manufacture of countless articles in our homes. Screens, springs, pins, plumbing fixtures, keys, bedsteads, lamps, locks, buttons, bird cages, buckles, and many more useful household things are made of brass. Copper and bronze are often used for making kitchen

utensils, though that is a custom more prevalent in some countries of Europe and Asia than in the United States.

The United States produces more copper than any other land in the world. Around Lake Superior and in Montana, Arizona, and Utah are found the largest mines. The ore is dug from the earth and the copper is extracted by various processes. By the so-called "wet" process the ore is crushed in big mills and is washed to take out dirt and impurities. By different kinds of roasting and burning in big furnaces other impurities are separated, and the pure copper is made ready to be cast in moulds. When this has cooled it is sold for manufacturing copper wire and other articles, or for the making of alloys such as brass and bronze.

THE STORY OF THE TIN CAN

Along the eastern coast of the Mediterranean Sea once lived a brave and adventurous people called the Phœnicians. Their country was small and did not provide a living for all its inhabitants. Long before other ancient peoples, the Phœnicians began to venture out on the sea in search of adventure, treasure, and wealth. They built good ships and voyaged farther and farther from home. They were really the world's first discoverers. By and by they sailed through the Strait of Gibraltar into the open ocean and discovered England. They began to trade with the people of that far-away land and to carry home to their own country strange things which they found there.

If you locate Cornwall on your map of England, you

will find that those sturdy Phœnicians ventured just as far as it was profitable to go. Cornwall is the westernmost part of England. It was there that they found tin. This shiny soft material must have delighted them, for they soon began to carry on an active trade with the Cornish tin-miners, taking home great shiploads of the metal. By melting tin with copper they obtained the useful, hard metal, bronze. They discovered many other uses for it; and since that time tin has been used by all civilized people of Europe.

The tin mines of Cornwall are the oldest known in the world. They are also the deepest, as some extend down into the earth more than 2,000 feet. These mines are still yielding tin, but larger deposits have been discovered elsewhere, so that only a small percentage of the world's tin supply now comes from Cornwall. The main source of tin to-day is in the Federated Malay States. There it occurs chiefly in river beds, and is collected by washing the tin-bearing soil in machines or trough-like sluices. Tin is also found in Bolivia, Australia, South Africa, and a few other countries.

Tin, when it has been separated from the soil and from other minerals found in the ore with it, is soft and shiny. It does not rust like iron and is therefore used for making containers which will be exposed to moisture and air. It can be pressed into very thin sheets, one thousandth of an inch thick, and in this form is used as tinfoil for wrapping candies, tobacco, and other things which must be kept dry. In thin sheets it is also used to make tubes for holding tooth paste, salves, and

library paste. Tin melts easily and for this reason is often used for solder in metal work.

The tin cans and cooking utensils which are so useful in our kitchens should really be called tin-plated ware. If they were made of pure tin they would be much too soft to be serviceable. They are made of sheets of steel which have been rolled very thin and then dipped into a bath of melted tin. The tin-plated sheets are pressed into the shape of the utensils, or they are cut by patterns into pieces which are then soldered together. When tinware rusts it is because the tin coating has been worn or melted off so that the steel is exposed. Empty tinware should not be left on the fire, as the tin will melt very quickly.

The tin can is perhaps one of the most useful articles made. It is used for packing almost every kind of meat, fish, vegetable, and fruit, and it carries food-stuffs to the ends of the earth. Have you ever thought how the tin can aids the explorer, the trapper, the prospector, the miner, and all men who must live away from civilization for many months at a time? Over one million tons of steel and ten thousand tons of tin are used every year in the manufacture of tinware. It is feared that the world's supply of this useful mineral will soon be exhausted. For this reason the price of tin has become much higher within recent years.

MAGIC FROM COMMON FIELD MUD

THE story of how aluminum was discovered and developed seems a fairy tale. It is now the youngest of our metals in common use. Only a few years ago its name

was not generally known and few knew of its existence. For thousands of years it was hidden in soil, rocks, and minerals in all parts of the world, and the greatest chemists of many countries had long sought to release and separate it from its surroundings. After two hundred years of experiments we now can see the magical change of common field mud into the light silvery metal which we use every day.

No other metal is found in greater abundance and no other is so carefully mixed with other substances in the earth's surface. It is never found alone, like silver and gold, but is always combined with other materials, such as clay and loam and several kinds of rocks and minerals, including many precious stones. Most of our aluminum in America comes from a mineral named bauxite, obtained from mines in Alabama, Georgia, and Arkansas.

The invention of the electric furnace a few years ago brought about the possible production of aluminum in large quantities for commercial use. The furious blasting heat of these furnaces requires especially strong electric current, which can be had only near cheap water-power, such as that furnished by Niagara Falls, where large aluminum plants are located.

The metal comes from the mills in the form of sheets, rods, or wires, which are spun, pressed, cast, stamped, or shaped by special manufacturers into a countless number of finished products desired in almost every industry. Kettles and spiders for the kitchen, fixtures for the bathroom, equipment and parts for the automobile, instruments and fittings for the aeroplane are

only a few of the best-known uses of aluminum. Being the lightest of commercial metals, yet almost as great in strength as steel, this amazing result of modern chemistry has done much to advance industrial development since the year 1855. It was then that the first article of aluminum, a baby rattle made for the Prince Imperial of France, was exhibited at the Paris Exposition.

AN ANCIENT ART IN OUR KITCHENS

WHEN you have looked at the enameled or "granite" cooking utensils in your kitchen you have never dreamed that they are closely related to some of the most beautiful jewelry and metal work made in ancient times. The art of enameling is very old, for it was used by the ancient Egyptians, the Romans, and the Greeks. It consists of covering metal or pottery with a glass-like mixture, which, by a process of baking in a very hot oven, turns into a smooth glaze.

The Egyptians and Assyrians built some of their wonderful temples of enameled bricks. Many ancient peoples made jewelry by a process of enameling and some of it was so beautiful, when made with different colored materials, that it looked as if set with shining precious stones. One of the most marvelous kinds of enamel work, called "cloisonné," originated among the peoples of the East. On a metal surface a delicate pattern is formed by thin, raised strips of metal like tiny fences. The spaces between these strips are filled with enamel of various colors. The piece is then baked in a very hot oven and cooled until the enamel mixture has become quite hard. Two or three coats of enamel

may be used, until the design is complete and beautiful. Such cloisonné work is still made in some countries. The Japanese excel in the making of all sorts of artistic enameled wares.

It was a clever thought which led to the use of the enameling process for making kitchen utensils. Enameled wares are more sanitary and look much cleaner and neater in our kitchens than iron and tinware. Moreover, the supply of tin in the world is becoming scarce, and it is fortunate that we do not have to use it so much as formerly for cooking utensils.

Enameled kitchen-wares are made of sheets of cast steel, covered with an enamel coating. The utensils are generally cut and shaped by powerful machinery. The handles are made separately and are fastened to the pieces either by riveting or by welding.

The enamel coat is made of a mixture of many substances, including quartz, feldspar, soda, borax, potash, saltpetre, clay, water, and some kind of coloring matter. As the manufacturers keep their methods of mixing quite secret, no two ways of making enamel are exactly alike. The materials are all melted together, being thoroughly stirred all the time, then poured while boiling hot into a tank of cold water. This sudden change in temperature toughens the mixture and also makes it brittle, so that it will grind easily. Grinding is the next process and it must be done very thoroughly until the mass is a fine powder. Water is then added to make a thin paste or "slip." The enamel is now ready to serve as a bath for the steel cooking utensils. They are dipped into the bath, dried, then sent into a fiercely

hot oven where the enamel forms a sort of glaze or glassy surface. Sometimes the dipping and firing are repeated three or four times to give a very thick coat of enamel.

For spotted enamel ware the coloring matter is left out of the slip and is put on afterwards by means of a brush or by a machine which sprays on the color like an atomizer.

Much of the clean white ware in our bathrooms is finished in practically the same way as cooking utensils, except that cast iron is used for bathtubs and wash-basins instead of cast steel.

Enameled ware should never be cleaned with acids, as these are apt to find a crack in the enamel and to eat the metal underneath. This makes a hollow place below the enamel so that it will begin to break. Enameled ware will crack also if placed over too hot a fire. This causes the metal to expand more rapidly than the enamel coat and, in trying to stretch, the enamel breaks.

HOW THE WORLD KEEPS CLEAN

HAVE you ever tried to scrub greasy cooking dishes without soap? If so, you can sympathize with the world in the time before soap was invented. It was quite unknown until near the beginning of what we call the Christian era, or about the time Christ was born. But by the time Pompeii was destroyed, in 79 A.D., the making of soap in Italy had progressed until it was a busy industry. The remains of a soap factory and some cakes of real soap have been found in the excavations at Pompeii.

All soaps are made by the action of an alkali on oils or fats. Liquid fats are composed of so-called fatty acids and glycerin. When an alkali (usually sodium or potassium) is added to fat, saponification takes place. That is, the metal in the alkali takes the place of the glycerin in the fat, and the glycerin settles to the bottom. The mixture left at the top is the soap.

Perhaps you have heard your grandmother tell of days long ago when every country family made its own soap. The housewife would save all the waste grease from meat cooked until a sufficient quantity was collected for soap-making. Her potassium she would get by pouring water through wood ashes, which are rich in potash. The grease and potash were then boiled together until thoroughly mixed. The mixture, when cooled, was a jelly-like stuff known as soft soap, as the action of potassium on fat forms a soft substance. To obtain hard soap, sodium had to be used, and the housewife would often add to the above mixture a solution of salt (sodium chloride). The sodium would change places with the potassium and the substance or soap would rise to the top. When cold it hardened into solid form and could be cut into cakes.

In the modern soap-factory the principles of soap-making are just the same as in the old days at the farmhouse. The difference is that everything is done by machinery and the soap is made in vast quantities. It is boiled in huge kettles so large that enough soap can be made at one cooking to fill ten or twelve freight cars. These kettles are heated by hot steam pipes. The ingredients, being in such large quantities, must

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be cooked more than a week in order to be thoroughly mixed. The soap is boiled many times over in order to be purified, and is then cooled for two weeks in huge vats or pans. After that it is run into a "crutcher," where it is beaten until quite smooth, and the perfume and coloring matter are added, if any are to be used. Next, it is run into moulds and placed in the drying room, where it remains until it is sufficiently hard to be passed through the cutting machines and made into bars of a desired size. These bars are again dried, pressed into cakes, stamped with the trade name, and wrapped. All these processes are done by machinery.

The vegetable oils which are used in soap-making are coconut, cottonseed, olive, palm, linseed, peanut, soy bean, sunflower seed, and many other kinds. The finest toilet soaps are made from olive oil and are usually called castile soaps, because they were first made in Castile, Spain. Transparent soaps are made either by leaving the glycerin in the soap or by dissolving the soap in alcohol. When the alcohol is taken out the substance remaining is thick and jelly-like. This is poured into moulds and allowed to dry. Floating soaps are made by forcing air into the soap mixture while it is still hot. When dry, the substance is light and will float on water.

Laundry soaps are made from a cheaper grade of fat or oil. The strong naphtha soaps, which remove grease spots so quickly in the laundry, are made by adding kerosene to the soap mixture. Scouring soaps have been made gritty by the addition of fine sand or powdered pumice-stone.

SEALING WAX

"The time has come," the Walrus said,
"To talk of many things;
Of shoes — and ships — and sealing wax —
Of cabbages — and kings."

PERHAPS you have thought that the Walrus had very little to talk about when he suggested sealing wax as one of the topics of conversation. But I am inclined to think that the Walrus was wise and knew some of the secrets hidden in sealing wax.

At the mention of sealing wax do you think of the daintily-perfumed little sticks of wax with which we sometimes seal our letters, or rather of the heavy, coarse, brown or red sticks which are often used for sealing cans of fruit? You are quite right in thinking of them as being entirely different, for one is made almost wholly of shellac and the other of ordinary resin, a product derived from the distillation of turpentine.

The story of shellac is the most interesting secret about sealing wax. Shellac is the sticky, resinous secretion or deposit of the lac insects which live in India. These insects, as they hatch out, attach themselves by the thousand to the twigs of certain kinds of trees. Here they secrete a resinous substance which forms a crust over themselves and the twigs. Many of the natives of India make their living by collecting the twigs of such trees after they have become thoroughly coated with the crude gum. After various purification processes the clear gum remains, and that sells on the market as shellac.

The finest grades of sealing wax are made chiefly of this shellac, to which, when melted, have been added certain amounts of turpentine and coloring matter. Perfumes are sometimes added also to give the delicate odor you have noticed when melting the wax for your letter seals.

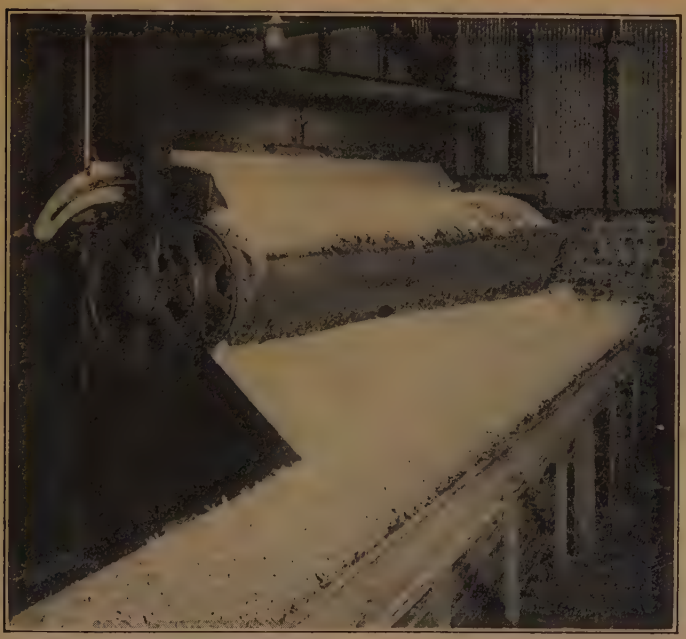
While the mass is still soft it is divided into pieces and rolled on a warm marble slab into little round sticks. By another process the melted substance is poured into moulds and assumes fancier shapes. Some fine grades of sealing wax have been made by pulling the soft shellac like taffy until it assumes an opaque, silky appearance. Coloring matters used in sealing wax are of various kinds. Lampblack is used for black wax, gold-colored mica for gold, Prussian blue for green, and ultramarine for blue.

The cheaper grades of sealing wax, such as are used for sealing cans, contain very little shellac. They are made chiefly of mineral matter, such as chalk, gypsum, kaolin, or zinc oxide, mixed with turpentine and rosin. The ingredients are usually ground together, mixed thoroughly, and moulded into sticks under pressure, instead of being fused by melting.

Sealing wax has been in use in Europe since the seventeenth century, when Venetian sailors brought it home from India on their long sea voyages. The Hindus had used wax for sealing their important letters, documents, and manuscripts from time immemorial. Their sealing wax was made of pure shellac, colored with vermilion or some other dye.

HOW THE WORLD'S FIRES ARE STARTED

ONE hundred years ago the kindling of a fire was a serious matter. Matches had not yet been invented



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MILLIONS OF MATCH SPLINTS READY TO ENTER DIPPING MACHINE

and household fires were usually started by means of the tinder box. In 1827 the principle of our modern match was understood, but it was not until many years later that the methods of manufacture were so improved as to produce the match as we know it to-day.

A modern machine completes the whole process of matchmaking, from the cutting of the wood to the final placing of the matches in their boxes. The wood — usually soft pine — is fed into the machine in layers of thin sheets. These are cut by the machine into splints the size of the match desired. The machine then forces these tiny splints into rows of holes in a moving screen or belt. This screen is in the form of an endless, traveling band, which, when bristling with its millions of splints of wood, resembles an enormous scrubbing brush.

The tips of the match splints are first carried on this moving belt through a melted-paraffin bath. Paraffin is used because it burns easily. The belt is so arranged that the matches are passing through the air long enough to become dry before being dipped into the next bath. This bath is an ignition paste, the mixture which forms the head of the match and which catches fire when the match is struck. This paste is usually made of phosphorus, sulphur, chlorate of potash, melted gum or glue, and some coloring matter. The phosphorus and sulphur both catch fire at low temperature, the right temperature being provided by friction when the match is struck, and the sulphur ensures a brightly burning flame. Some modern machines carry the matches through two ignition baths, but the mixtures usually contain, with slight variations, the same materials.

By means of a recent improvement in the manufacture of matches the stems are soaked with some fire-resisting chemical, such as sulphate of ammonia, so

that the flame dies shortly after it has passed the head of the match.

After passing through the ignition bath the matches are carried slowly on the moving belt for about an hour,

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THIS MACHINE CARRIES AND DIPS ONE MILLION MATCHES AT A TIME

or until they are thoroughly dry. The finished matches are then automatically pushed out into their boxes, which are usually made in the same factory.

In the ignition bath for the safety match the phos-

phorus is omitted, but it is included in a mixture smeared on tne outside of the box. The match will not light except when it is rubbed against the outer surface of its box.

A single match factory can make about 100,000,000 matches per day. This is not too many to satisfy the demand, for it is estimated that for every person in the civilized world eight matches a day are needed. The United States imports most of its matches from Sweden and Japan.

SWEEPING COBWEBS OUT OF THE SKY

No one knows how long brooms have been in use. They must be very old, for when people knew no better than to believe in witches they always thought of them with brooms. They believed that the witches swept the sky to keep it clean. Probably the first broom was a rude bundle of twigs or branches which the cave woman carried in from the woods to brush out her cave home. In many parts of the world, even in some of the more civilized countries of Europe, brooms are still made of twigs tied to a handle.

Our best brooms to-day are made of broom corn, a kind of sorghum which resembles corn and which has a branched top filled with seeds. Just when man began to use this plant for making brooms is unknown, but we do know that broom corn was cultivated and used for brooms in Italy at least two hundred and fifty years ago.

Brooms were first made at home. In colonial times many farmers spent the long winter evenings making

brooms as they sat about their open fires. Besides the broom corn they used also corn husks, hog bristles, and wood. So-called Indian brooms were made of sticks of wood splintered at one end so that they could be used for brushing and sweeping.

Broom corn is raised in many parts of the United States, but chiefly in the Mississippi Valley. The stalks are cut while still quite green, as the fibres become brittle and break easily if allowed to remain in the field until the seeds are ripe. The heads are cut off and stems and twigs are thoroughly dried, after which the material is ready to be wrapped in huge bundles and shipped to the broom factories.

Nowadays brooms are made in this country chiefly by machinery, though in many places they are still made by hand. The cornstalks are first washed thoroughly, then dipped into a green dye which gives them the bright attractive color which we always see in a new broom. The fibres are then sorted according to length and coarseness, as the shorter lengths are used for making smaller brooms and the coarser fibres are used for the insides of the brooms.

The fibres are gathered about the handle of the broom and a winding machine wraps the ends tightly to the handle with wire. The broom, which is now round or cone-shaped, is then placed in a clamp or vise which flattens it into the shape which we think of as belonging to the broom. It is then sewed with heavy cord, either by hand or by machine. After a scraping machine has removed any seeds which may still be clinging to the fibres and the end of the broom has

been cut even, the article is finished and ready for the market.

The broom has until very recently held undisputed sway in the household as the chief article for cleaning carpets and floors. The carpet-sweeper has partially taken its place, and the vacuum cleaner is coming more and more into use. The carpet-sweeper is a combination of brush and dustpan, so arranged that the brush moves round on a roller, sweeping the carpet as it turns and gathering the dust and coarse dirt into a closed box.

The vacuum cleaner works by means of suction. That is, a current of air sucks the dust and dirt from the carpet up into a bag or container of some kind. The best vacuum cleaners are run by electricity, but the smaller hand-machines are much less expensive and are used in many homes.

HOW MANKIND HAS LEARNED FROM THE BIRDS

THE basket has probably served more useful purposes in the world's history than almost any other thing which mankind has learned to make. All through the ages savage women have known how to make baskets and have used them for all kinds of purposes in their households. There are older basket-makers than the savage woman, however, and those are the birds. The idea of weaving grasses, twigs, and sticks into a utensil for holding and carrying things probably occurred first to the primitive woman when she looked at the neatly made nests of the birds in the forests about her.

The American Indians developed the art of making baskets until they were very lovely. Many of them were made of different-colored grasses and woven into

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HOPI INDIANS WEAVING ARTISTIC BASKETS

beautiful patterns, ornamented, perhaps, with shells, quills, or other natural decorations. The basket was the Indian woman's most important household utensil. She used baskets for carrying food and water; she used them as dishes, as cooking utensils, and as papoose

cradles. You will ask how she could carry water or cook food in a basket. Some Indians used a coating of resin from the pine tree for the baskets which were to be used for water, but others wove their baskets so tightly that they held water quite safely without leaking. They boiled food in these baskets by dropping hot stones into the water.

The savage warrior also found many uses for baskets. His canoe was often a woven basket covered with hides; his shield was sometimes a tightly woven protection made of grasses very much as baskets were made; and his coffin was likewise a beautifully woven basket. So from the cradle to the grave primitive people have found the basket a most useful and necessary tool.

Baskets are still made chiefly by hand. For this reason many of our disabled soldiers learned basket-making as a means of making a living. Many materials are used for basket-making. The one in widest use is the young branch or shoot from the willow tree. These branches or osiers are usually cut once a year, so that they are young and pliable. Older ones are used for the stouter parts of the basket. Rushes, bamboo, rattan, and raffia are used a great deal, as well as grasses and strips of strong, pliable wood such as hickory. Rattan is the stem of a vine — a kind of climbing palm which grows in India. These vines often grow to a great length and twine about the trees or hang in great loops or festoons from tree branches. Raffia is a soft yellowish material which comes from the leaf-stalks of a kind of palm that grows in Madagascar.

Baskets are made either by weaving or by sewing. The woven baskets are built up by twining or lacing the basket material about a warp or frame usually made of stronger fibres. The shape of the basket depends on this frame. The sewed basket is made by continually stitching a coil of fibre or grass, laying coil upon coil and forming the shape as the basket grows.

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WEAVING COMMERCIAL BASKETS BY HAND

A machine has recently been invented which can manufacture wicker-ware. It weaves the solid part of the basket separate from the frame and is coming into use for plain, heavy basket-ware. The most beautiful baskets, however, will no doubt always be made by hand.

WHAT SHOULD WE DO WITHOUT BOXES?

THE storekeeper would have a hard time if there were no boxes in which to keep his supplies. The manufacturer would be even more inconvenienced if he had no boxes in which to pack his goods for shipping and selling. Even in our own homes we should find it very difficult to keep house without the neat boxes in which

we pack and store things. And what should we do when we went shopping if many of our purchases could not be carried home in boxes? The storekeeper no doubt realizes how fond we are of boxes, for he sets out his wares in the very prettiest ones he can find, so that he may entice us to buy. I have no doubt we purchase many things we do not need, because they look so nice in their cases.

Most boxes are made either of paper or of wood, though we frequently see them made of metal, such as tin or even iron. Paper is used more and more in place of wood for box-making. This is fortunate, for so much lumber is used in making wooden boxes that many thousands of beautiful trees must be cut down each year for that purpose. Paper boxes are so much lighter than wooden boxes and can be made so much safer for packing breakable articles that manufacturers are using them in larger quantities each year. Round paper boxes, or cans, are even used now to a large extent, instead of tin cans, for packing breakfast foods, baking powders, tea, coffee, and cleaning powders.

Nearly all the paper for boxes is itself made of waste paper, though some, known as strawboard, is made of straw. For ordinary paper boxes much of the waste paper which is collected from our streets and homes goes into the grinding machines. Old newspapers, confetti, old posters, and used wrapping paper of all kinds are ground together and made into pulp. The pulp is pressed and dried into sheets or boards; then it is ready for box-making.

Paper boxes are made almost entirely by machinery.

A machine cuts the boards and creases them where they are to be folded. Another machine cuts out the corners, so that the boards will fold, and still another one bends up the sides and ends. Strips of gummed paper are then attached by machinery to the corners of the boxes, so that they will hold their shape. The lids of the boxes are made in just the same way. Most boxes are then covered, either with white, colored, or decorated paper. The paper covers are cut by machine but are usually put on by hand.

You have no doubt seen another kind of paper box, the sides of which look as if they had been marcelled. This is called a corrugated paper box and is usually made of strawboard. This kind of box is very good for shipping glassware and other breakable articles, as the sides are like cushions. The "curling" or corrugation of the paperboard is formed by pressure in a machine. The same machine can line the corrugated paper with a plain sheet of strawboard on one or both sides. The unlined corrugated paper is used for packing, lining, and padding other boxes. The sheets which are lined on one side are used largely for making tubes for packing glass articles, such as electric-light bulbs. From the double-lined sheets all kinds and shapes of shipping boxes are made. The corrugated boards are cut and folded into boxes by machinery, much as are the plain paper ones.

Wooden boxes are made of many kinds of lumber. The thin ones must be made of hardwood, such as beech, maple, birch, ash, or oak, as the sides would split when nailed if made of softwoods. Over four billion feet

of lumber are used every year in wooden boxes. A machine has been invented which can nail the parts of a wooden box together. It is so constructed that when it drives the nail the point is curved back into a hook. This holds the boards together very securely, so that the box is hard to open. As there is great danger of theft when goods are shipped a long distance with no one to look after them, boxes made by this machine are much safer than wooden boxes which have been nailed together by hand.

MEASURING HEAT

WHAT makes the mercury in a thermometer rise and fall? How does it measure heat?

More than three hundred years ago a famous Italian astronomer, Galileo, answered these questions by making the first thermometer. This same Galileo was also the first scientist to use the telescope to study the stars and the first to discover the use of a swinging weight to measure time, which developed into the wonderful invention of clocks.

There are two ways of measuring heat, by degree and by quantity or amount of heat. Thermometers are made to measure degrees of heat, which we call temperature. Our most common thermometers are mercury thermometers, measuring the temperature by the rise and fall of the mercury in the glass tube.

Mercury is an odd liquid metal, sometimes called quicksilver. It does not freeze easily — not until the thermometer reaches 40 degrees below zero; and it can stand great heat before reaching the boiling-point.

Heat causes the mercury to expand and rise in the glass tube of the thermometer and cold contracts it, causing it to fall in the tube. On the glass tube, or back of it, you will find both marks and figures arranged as a scale for indicating the changes in temperature. The degree marked "freezing" is the freezing-point of water, which on the Fahrenheit scale is numbered 32, using 0 (zero) as the beginning-point.

Alcohol is often used in place of mercury, for it freezes at a much lower temperature.

There are many special kinds of thermometers made for special purposes — gas, electrical, steam, cooking, and so forth. One of the most interesting is the kind used by the doctor, which he places under your tongue to measure the temperature of your blood and show your degree of fever, and which he afterward must shake to lower the mercury below the little pocket in the tube. At the Weather Bureau stations you will find thermometers which record the highest and lowest temperatures reached during the day or night. Some have charts which move by clockwork, with the changes in temperature traced in ink by a revolving needle. The world owes much to Galileo.

HOW HEAT PRODUCES COLD

THINK how necessary ice is to our comfort and health to-day, and then try to imagine a time without it. It seems strange that man did not learn sooner how easy it is to cut and store ice in winter for summer use. The first house for storing natural ice was not built until 1805. The real value of ice was not generally realized

until about the time of the Civil War (1860–1865). It was then in great demand in the military hospitals, where the wounded soldiers suffered so much from fever.

Since the middle of the last century machines have been invented for making artificial ice and it has become a very important article in our everyday life. Besides adding much to our pleasure and comfort in the summer time with cold drinks and the preservation of foods, it has become a necessary article of commerce. By the use of refrigerator freight-cars it is now possible to ship great distances meat, eggs, fruits, and other perishable foods. Ice is of great service in hospitals and for the treatment of the sick. If it were not possible during the hot summer months to preserve milk by means of ice, many babies would die from drinking sour milk.

America is really the mother of the ice industry. Other countries have learned from us our methods of cutting and storing natural ice, and it is in this country that ice-making machines have been invented and first put into use.

Artificial ice is manufactured much as ice-cream is made. According to one method, cans of water are lowered into a large tank or vat filled with ice-cold brine or salt water. Brine does not freeze until it reaches zero, and as water freezes at 32 degrees above zero the water in the cans turns to ice when the brine reaches a temperature of 25 to 12 degrees above zero.

An interesting thing about ice manufacture is the way in which the brine itself is cooled. The process is based on the fact that when evaporation takes place the

temperature becomes lower. You know that your wet hand feels cool even when you have dipped it in warm water. Wet clothes also feel cold to the touch. This is due to the fact that the water is evaporating. Some substances evaporate much more rapidly than water and consequently produce more cold. Ammonia is one of these substances. It evaporates so rapidly that it must be kept under heavy pressure to keep it in liquid form.

For the ice-making machines liquid ammonia is kept in a tank under enormous pressure. This ammonia is allowed to flow into pipes which run through the vat filled with brine. As soon as the ammonia is released into the pipes it begins to evaporate and makes the pipes extremely cold. These pipes cool the brine, and it in turn freezes the water in the cans which have been lowered into the brine. From twenty-four to thirty-six hours are required for freezing the water into large blocks of solid ice. Many cans may be frozen at a time, so that a large ice-making plant can turn out many tons of ice a day. When the cans are frozen solid they are lifted out by an enormous hook or crane and dipped for a moment into a tank of boiling water. This melts the outside of the ice blocks sufficiently for them to be taken from the cans.

When the evaporated ammonia (or ammonia gas) has passed through the pipes in the brine tank it is cooled by running water over the pipes and returned to the heavy compressor, where it is once more forced into liquid form, ready to be used over again. These compressors are run by an engine using some form of heat, so that

what really takes place in an ice-making plant is the production of cold by means of heat.

Although most of our ice is now made artificially, a great deal of natural ice is still used. This is, of course, harvested during the winter when the surface of lakes and streams is frozen over. The surface of the ice is scraped to remove snow and dirt, and a machine is then drawn over the ice, marking it off in grooves. Another heavy machine fitted with big saws then passes over the ice, cutting it nearly through. Men complete the work with handsaws, and the cakes of ice are floated down the stream or lake to an ice-house. In the ice-house the ice is kept from melting by coating each cake with sawdust. It is shipped out from these storage houses on boats or freight cars or trucks.

Artificial ice is much purer and cleaner than natural ice. It is generally made of distilled water, or water which has been first converted into steam to be thoroughly purified, and then condensed again to water.

PROTECTING OUR FOOD FROM DECAY

It has been known for a long time that food decays or spoils much more rapidly in warm air. For this reason man learned quite a long time ago to keep his food in the coolest places he could find. If his house had a cellar he discovered that it was much cooler than the upper part of the house, and so milk, butter, and eggs were kept there. We have learned that whenever a liquid evaporates it produces coolness. For this reason the temperature around a body of water is always cooler than elsewhere, because the water is constantly evapo-

rating. Fifty or sixty years ago nearly every farmer had his milk-house or spring-house where foods could be kept during the warm months of summer. The spring-house was built over a well, a spring, or a brook, where the evaporation of water could be made to help keep the food cool.

None of these methods for preserving food were perfect, because they did not keep the food cool enough. It has been discovered that the decaying of food is really due to the work of thousands of little bacteria. Bacteria are tiny plant-growths so small that they cannot be seen except with the aid of a strong microscope. In fact, they are so minute that a thousand of them could rest comfortably on the head of a pin. These things are in the air all about us. Most of them are quite harmless; some are wholesome and helpful; but some are very dangerous to our health and even cause disease. When those harmful bacteria reach food they cause a change, which we call decay, to take place in it, so that it is no longer fit to be eaten. But since those kinds of bacteria cannot work well except in warm, moist places, food keeps much longer if it is placed in a cold, dry spot.

This explains why we have refrigerators in our homes. These refrigerators are kept cool by means of ice in the ice-box and provide the cool, dry air necessary to preserve our foods. You know already that the upper part of a room is always warmer than the lower part. This is because warm air is lighter than cold air and is always pushed to the top. The work of the refrigerator is based on this fact. The air nearest the ice becomes

cold, as ice in melting absorbs the heat all around it. This cold, heavy air falls to the bottom of the refrigerator, but the farther away from the ice it moves the warmer it becomes again, absorbing heat from the food and the walls of the refrigerator. The cold air coming from the ice-box continually pushes the warmer air out of its way, and so keeps up a constant moving or circulation of the air in the refrigerator.

This keeps the food cool; but it must also be kept dry. One would think that the melting ice would make too much moisture. But cold air can hold very little moisture, and as it becomes warmer it picks up moisture from its surroundings. Because of this fact, the cold air, as it is warmed in passing over the food, absorbs moisture from it. Thus you see a refrigerator is a very clever invention for keeping our food cool and dry.

The walls of a refrigerator are usually made of several thicknesses of material. Between the inner and outer layers of the walls an air space is left, which is packed with some substance that does not carry heat well. This may be charcoal, felt, some kind of paper, or perhaps mineral wool. It helps to keep the warm air of the room out of the refrigerator. The best refrigerators are lined inside with porcelain, enamel, or glass, but the cheaper ones are lined very well with galvanized iron or zinc. The shelves are of metal or heavy wire screening. The wood used in making refrigerators must be as nearly as possible without odor, for you know how such foods as butter will absorb odors from other things. Elm wood is one of the most satisfactory for this purpose.

Some refrigerators require no ice at all. These iceless refrigerators make the air cold by another means. You remember that artificial ice is made by the evaporating of liquid ammonia. These refrigerators depend on the same kind of process. A little electric motor is used to run a compressing machine which presses the ammonia gas into a liquid. When the liquid is released from pressure and turned into tubes that run through the inside of the refrigerator, it evaporates again and creates cold. The ammonia tubes or coils in an iceless refrigerator are always covered with frost, because they are so cold. These cold tubes serve the same purpose as blocks of ice.

THE CLOTH THAT WILL NOT BURN

THE asbestos mats which we use as protection against heat certainly do not look as if they had been dug from the earth. Asbestos, however, really is a mineral, which is found in the earth and must be mined or dug out, much as stone is quarried. Asbestos will not burn, rust, or decay, as so many minerals do, hence it is of great value for protection against fire and heat of all kinds.

The material as it is first found is quite heavy; but it contains a fibre which is as soft and delicate as thistledown. The first process through which the mineral must pass takes place in a "chaser," which crushes the material, separates the rocky, crystalline part, and leaves a mass of snowy-white stuff that is sometimes called "mineral wool." The next process is that of winnowing, by which a strong blast of air separates and blows away the bits of rock which are still clinging

to the wool. The fibres themselves are then gently blown or raised again by a current of air, and during this process they settle according to their weight and texture, so that the finer ones are left on top. In the carding-room a machine straightens the fibres and lays them parallel.

By courtesy of the United States Department of Agriculture

INTERESTING SAMPLES OF ASBESTOS

The fibres are then spun into a sort of yarn if they are to be used for asbestos cloth. There are many uses for this cloth. Some of us have asbestos covers on our dining-tables under the linen cloth, in order to protect them from damage by hot dishes. You have probably noticed the word, ASBESTOS, in large letters on the heavy curtain which hangs in front of a theatre stage. Such curtains are made of asbestos and are one of the requirements for protection of the audience in our theatres.

These curtains must be made from absolutely pure asbestos, so that they may be thoroughly fireproof and possess the greatest degree of strength. The scenery used in theatres is often made of or covered with asbestos.

Cheaper grades of asbestos, coming from the coarser fibres and from poorer qualities, are made up into compressed fibre-boards which are used for fireproof roofing, for inner flooring, and for insulation in walls. That is, an inner fireproof wall is often built inside the walls you see, for the purpose of protection against the spread of fire. Heavy asbestos cloth is used for wrapping the heating pipes of our house furnaces, for the purpose of preserving heat. Pipes so covered will not let so much heat escape, and so they carry most of the hot air to its proper destination in the house.

Asbestos is used in many other ways. Fine asbestos cloth is made into suits for firemen and into aprons for chemists who must work a great deal near open flames. Asbestos is used in making shoe soles for use in factories where metal floors become very hot. A rather new use for asbestos is in automobile brakes. A substance like this greatly reduces the heat which results when two metal surfaces rub together, as occurs in the use of the brake of an automobile. A kind of fireproof building-material is made from a mixture of cement and asbestos. This is used for the manufacture of safes, filing-cabinets, and booths for moving-picture machines, with their films which catch fire so easily.

Asbestos has been known to man a very long time. The Greeks probably knew about it, as its name comes

from a Greek word meaning unburnable. Charlemagne is said to have had an asbestos tablecloth with which he astonished his guests, throwing it into the fire to prove that it would not burn.

HEATING OUR HOUSES

EVER since man learned the value of fire he has been using it for warmth and for cooking his food. The cave man heated his home by building a fire on the floor of his cave and getting along with the smoke as best he could. When man learned to build tents or wigwams he made his fire on the floor, but left a hole at the top of the tent for the smoke to escape.

The Greeks and Romans generally heated the rooms of their houses with little pots or braziers of burning charcoal. The Romans knew still better ways of heating than this, however, for their great bathhouses, which were so famous, were warmed by pipes filled with hot water. This method was the ancestor of our hot-water heating systems. Some Roman houses were heated by "hypocausts" or fire-rooms in the basements. Great fires would be built in those rooms and clay pipes carried the heat — and the smoke — to the rooms above. This could not have been very pleasant, although a house so heated may have been comfortably warm. Chimneys for carrying off the smoke from fires were not invented until several hundred years later.

Stoves made of porcelain and tiles, such as are still found in many parts of Europe, came into use toward the end of the fifteenth century. These are large square or round structures, reaching from the floor almost to

the ceiling. The fuel is burned in a small fire-box near the bottom of the stove, and the hot air, as it passes through the upper part, so thoroughly heats the porcelain that the surfaces of the stove can in their turn help bring the temperature of the room up to a comfortable degree.

During early Colonial days in the United States the only method of heating was by means of the open fireplace. This method was poor, as most of the heat went up the chimney instead of warming the room. People suffered a great deal from cold in those early days. Sometimes ink would freeze on their pens as they sat beside the fire. Usually there was a fireplace only in the living-room. The sleeping-rooms sometimes had fireplaces, but often were not heated at all. The living-room fireplace was used for cooking as well as heating. It was provided with cranes on which long hooks were hung, to hold iron pots over the fire. There was usually a brick oven built in the wall at the side of the fireplace, where baking was done once a week. A fire was built inside the oven and kept burning until the brick walls were very hot. The ashes were then raked out and the bread and cakes placed inside to bake. Some kinds of food were baked in iron pans with tight covers, the pans having long iron legs and standing at the edge of the fire, astride a heap of hot coals. Meat was roasted by being fastened on a "spit" or sharpened stick hanging over or in front of the fire. It was so arranged that a child could keep the spit turning around and thus cook all sides of the meat alike.

Stoves were not introduced into the United States

until about 1730. These were simple iron boxes with doors through which the fuel could be put in and openings at the top to let out the smoke. In 1744 Benjamin Franklin invented an open stove which was a kind of movable fireplace. It was made of iron, and as it stood out in the room, away from the wall, it could throw out heat on all sides.

Since that time stoves used for heating and for cooking have been greatly improved, so that they are now really small hot-air furnaces. They are made with a grate or fire-box inside, which heats the cold air as it comes in from the bottom. The air circulates about the fire-box, becomes hot and passes out through the top of the stove to heat the air in the room. Cooking stoves and ranges now in use are made with a baking oven around which the hot air circulates, and with a flat top on which cooking utensils can be placed. Stoves are usually made of a good grade of cast iron, which throws out heat successfully.

The custom of warming houses by means of a large stove or furnace in the basement has become more and more common. Although it may cost more to put a furnace into a house than it does to buy stoves for the various rooms, we have learned that the furnace uses less fuel, makes the house a more comfortable place, and causes much less trouble. There are three methods of furnace heating: the hot-air, the hot-water, and the steam heating systems. The hot-air system is the cheapest and most simple. A hot-air furnace is practically a big stove, which is provided with pipes for carrying the heated air to the various rooms of the house.

The pipes are generally covered with sheets of asbestos, which hold the heat inside until the pipe reaches the room where warmth is wanted.

By means of a hot-water system a water-heater is located in the basement, and from this hot water is carried through asbestos-covered pipes to radiators in the various rooms. As the water flows through the radiators it cools and then flows back again to the basement to be reheated. The same water is thus used over and over again. Cold water is heavier than hot water, and so keeps pushing the hot water out of its way all the time. This pressure keeps up the flow or circulation of the water through the pipes.

A steam heating system looks much like a hot-water system. The heater in the basement, however, is really a boiler, which makes the water so hot that it turns to steam. As more and more steam collects in the boiler, its pressure becomes strong enough to force the steam through the pipes and into radiators in various parts of the house. In the radiators, which are cooled by the air in the rooms, the steam loses some of its heat and changes back into water. In this form it flows back to the boiler. When the steam changes to water it loses exactly as much heat as was required to turn the water into steam. This heat warms the radiator and, in turn, the room. As steam can be carried farther than hot water or hot air, this system is the best one for large buildings or groups of buildings which depend on a central heating plant.

PART IV

IN THE BASEMENT AND LAUNDRY

FROM FOREST TO COAL BIN

PERHAPS you have sometimes noticed on a big piece of black coal the print of something which looked like a leaf or fern. Would you be much surprised to learn that it really was the print of a leaf which lived centuries and centuries ago?

The story of coal seems like magic. In districts where the world's great coal-beds are now located were once low marshy places or swamps. A great change has taken place on the face of the earth since that far-off time, and places which were once low or perhaps near the sea are now quite high and even hundreds of miles away from the sea. The climate in that bygone time was also much hotter in many places than it is to-day. If you have ever seen a swamp in a hot climate you know that the damp soil and the sunlight encourage plants and trees to grow to an enormous size and to live so close together that they form dense forests.

Millions of years ago such swamps were filled with huge trees, giant ferns, and other enormous plants. As the trees and plants died they fell into the water and became buried, in the course of centuries, under other trees and plants which died after them. When a dead

plant lies on the ground in the open air it decays and changes gradually into gas and ashes. But in the water of these swamps, where air could not reach the woody material, something else took place. Instead of decaying completely in the ordinary way the bodies of dead plants and trees changed into a substance like the peat in old bogs. As long centuries passed, and the pressure from more and more layers of fallen tree-trunks became heavier and heavier, the peat changed to the hard black substance which we call coal. In places where the pressure was greatest and where heat from inside the earth could reach the coal, it became almost rock-like. That kind of hard coal is called anthracite. By some tremendous disturbance down inside the earth ages ago many of these swampy places were pushed up out of ancient lowlands, so our coal beds to-day are in dry spots where they can be mined.

Coal was discovered long ago in some countries. The Romans found the inhabitants of England and Scotland using coal at the time they conquered Britain. That was almost two thousand years ago. Coal has probably been used by the Chinese many hundreds of years. In the United States coal was discovered in Virginia in 1701, but it was not mined much until almost one hundred years later. During the nineteenth century coal became one of the most necessary materials used by man. One of its most important uses is supplying heat for iron manufacture. If there were no iron, most of our great industries could never have been developed, because of lack of machinery. Coal is used for making the steam which runs our railway locomotives and other

engines of many sorts. The gas which we use for cooking and lighting is made from soft coal. We use a vast amount of coal in heating our houses and factories and shops and office buildings. From coal tar modern chemists have learned to make perfumes, beautiful dyes, powerful explosives, and many other useful things.

Coal is dug or mined from its dark beds deep down inside the earth by men called miners. The life of the miner is a dangerous one. The walls of the mines sometimes cave in. Poisonous gases in the mines may cause death. Other gases, which catch fire easily, occasionally cause explosions in coal mines. Many inventions have been made to render the miner's life less perilous. Because the mines are dark, each miner must wear on his cap a little lamp to light his way. When an oil lamp with an open flame was used, explosions were very apt to occur if the miner came in contact with certain kinds of gases. But there are now little electric lamps for the miners and these are quite safe. There are also masks, such as soldiers wear in war time, and by means of these the miners can protect themselves from poisonous gases.

In the early days of mining most of the digging of the coal was done by hand picks. This was very hard when the excavation where a man worked was so shallow that he could not stand up straight, but had to work with his pick all day long stooping over or even lying down. Modern coal-mines now make use of machinery for most of the loosening and digging of the coal. There are also machines with revolving shovels which scoop up the coal and load it on cars. Such cars used to be pulled

by mules that spent months down in the mines without ever seeing the daylight; but in most mines electricity is now used to run the cars and also to operate the machines or "hoists" that carry the coal to the top of the mine. From the mine the coal is either stored in huge bins or is loaded at once on freight cars ready to be shipped to the coal-dealers who sell it to us.

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ELECTRIC COAL CUTTER IN COAL MINE

Coke is an excellent fuel which is made by burning coal in a closed oven or "retort" where little oxygen can reach it. The gases in the coal pass off through pipes, the tar oozes out, and the remaining substance, which is coke, is very hard and brittle. When coke itself is burned it makes a great heat and does not throw off smoke like coal. It is used in melting mineral ores, such as iron, and is also an excellent fuel for burning in our house furnaces.

Coal, as we have seen, is very necessary to man's comfort. Yet the world's supply of coal is being used up

very fast. When we have dug all the coal out of all the coal-beds there will be no more, for it cannot be replaced. Some people say that if we keep on using coal as rapidly as at present we shall have used it all up in one hundred and twenty years. We must learn to manage more carefully and not waste it, or the world will have a hard time some day.

HOW MAN LEARNED TO USE THE SACRED FIRES

THE gas which we burn in our kitchen stoves and sometimes use for lighting our houses seems to us such an ordinary thing that we are apt to forget how wonderful it would appear if we were seeing it for the first time. We think little about it, except that we notice it has a bad smell and we know that we must not breathe much of it, because it is poisonous.

Some early peoples discovered in their homelands a mysterious invisible vapor which came from cracks in the earth and would burn with a beautiful flame. Many of them built temples over those spots and made them places of worship. Some of those places are still considered sacred by the people of the East, and the flames have been burning steadily for centuries. The Indians of North America knew also of spots where such vapor rose from the earth and they considered the fires which they could light there quite mysterious and magical.

This wonderful vapor, which so astonished people who knew nothing about science, was natural gas such as occurs in large quantities in the United States and

which we use to-day for lighting and heating our homes. Gas is usually most plentiful in regions where petroleum is to be found. It collects in "pockets" between the rocks deep down inside the earth, and can be reached only by drilling or boring wells. Some gas wells are 250 feet deep, while others must be bored 3,000 feet before the gas is reached.

The first gas well in the United States was found by accident. Some men were boring for a salt-water well and unexpectedly reached gas. When flames burst from the earth the men were terrified. They thought they had drilled through to the underworld, which they believed to be deep inside the earth. This was about the year 1800. Since that time the use of natural gas has gradually increased until to-day there are more than three million people using it for heating, cooking, lighting, or for manufacturing purposes. The gas is carried in pipes from a well to the consumers or people who use it. Sometimes pipes carry the gas more than a hundred miles across the country from the wells to some large city.

In the early days of natural gas people supposed that it would last forever and used it wastefully. Great wells were left burning for days and nights just because people liked to see the wonderful flames shooting up into the sky. Farmers in the country sometimes allowed enormous flames to burn all night in the open air, so that insects attracted to the light and killed by the heat might be used to feed their chickens the next day. We have since learned that, just like coal and petroleum, the supply of natural gas can be wasted, so we are now trying to use it only as we need it. The supply of

natural gas has been quite exhausted in some parts of the United States, but new wells are still being opened in other parts all the time. Natural gas burns with a clean hot flame and is the cheapest kind of fuel known. It is more used in the United States than in any other country.

Since our supply of natural gas has entirely disappeared in portions of the United States, it is fortunate that we know how to manufacture a gas which is almost as good for lighting and heating. This gas is made from coal, and is sometimes called coal gas, though we usually speak of it as illuminating gas.

Quite early in the eighteenth century scientists discovered that a gas could be obtained from coal which would burn with a yellow flame; but no one ever tried to light a house with it until 1792. A Scotchman by the name of William Murdock then made a little gas-plant of his own and astonished his neighbors by lighting his house much more brightly than they could with their lamps or candles. By 1807 Murdock had proven the value of his gas so successfully that the streets of London were lighted with it. Before that time city streets had been lighted either with lanterns which people hung outside their doors or by street-lamps burning oil, which required a great deal of care. At first people were afraid of the new gas, fearing that the pipes were filled with flames.

Illuminating gas is made by heating coal in air-tight brick ovens or retorts, under which hot fires are built. The gases which are stored in coal pass out through pipes when the coal is thus heated; but they must be

purified before they can be used for burning. They are passed through water, which washes out many of the impurities, and through layers of some chemical, such as lime, which removes sulphur and carbonic acid and other materials not wanted. The gas is then conducted in pipes to huge round storage-tanks. These are built so that they float over large basins or cisterns filled with water, and they rise and fall with the large or small supply of gas which they contain.

From these tanks gas is carried all over a city in large pipes, called mains. From these mains smaller pipes, called service pipes, carry the gas to the homes and other buildings where it is to be used. Each consumer is provided with a machine called a meter which measures the amount of gas he uses each month, so that he may pay the proper amount to the gas company. Artificial gas is not used as much now as formerly. This is because coal is becoming more expensive all the time and also because electricity is better for lighting and its home uses are increasing in number.

There is still another kind of artificial gas, called water gas, that is used in some places instead of gas from coal. These gases, both natural and artificial, are indeed mighty forces from the unseen, creating heat, light, and power when properly controlled by the hand of man.

THE OIL WELL AND ITS LARGE FAMILY

You would never dream that the gasoline which is used to drive our motor cars had such a number of brothers and sisters. The kerosene or "coal oil" which your

mother perhaps uses in her kitchen stove, the clean fuel-oil with which your neighbor heats his house, the paraffin from which our Christmas candles are made, the petrolatum or vaseline which feels so soothing on burned or chafed skin, the asphalt which is used in so many of our city street pavements, the queer-smelling benzine with which dry-cleaners take out grease spots — these are all related to gasoline. They all belong to the very large petroleum family which lives so comfortably underground until someone drills a hole down into its bed and starts an oil well.

Petroleum, as it first comes up from the well, is a thick, dark, bluish-brown oil. It does not look as if it contained all these substances. In fact it looks quite uninteresting and worthless. Because of this it took the world a long time to find out just how useful it could be. It had been known in various parts of the world for many hundreds of years, but was very little used until recently. Because it came from the earth and would burn, making a beautiful fire, in some parts of the world it seemed to man to be magic, and he considered it a gift direct from the gods. For this reason it was burned in religious ceremonies in some countries. In the temple of Jupiter at Rome it was used for burning in the lamps.

When white men came to North America they found the Seneca Indians using petroleum for medicine. The oil, when occurring near the surface of the earth, often collects as scum on ponds and lakes. The Indian medicine-men considered this very powerful in healing qualities and collected it for medical use. They tried

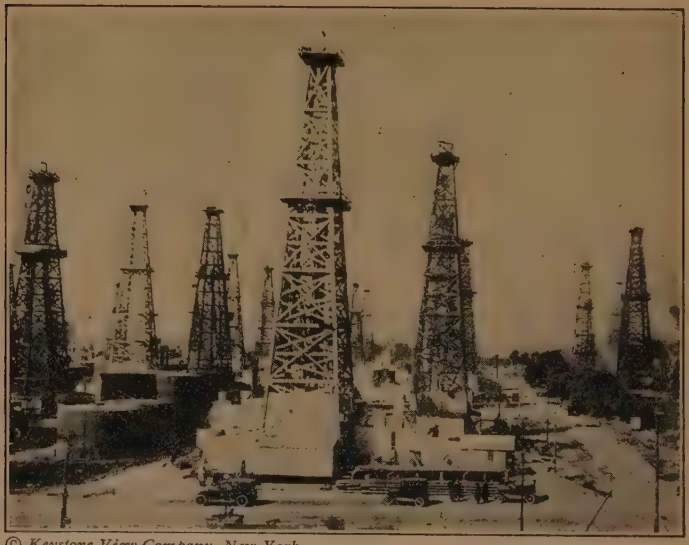
to persuade the white man to use it also, but he did not like its bad taste and its foul odor. For a long time petroleum was called "Seneca oil." Since we have learned to make vaseline we know that the old medicine-men were right about the healing powers of their strong oil.

In early Colonial times in the United States people burned whale oil in their lamps. But about 1840 the supply of this oil was threatening to become scarce. A method was worked out for extracting oil from a kind of soft coal. This "coal oil" became popular and people learned to use it for lighting instead of whale oil. Then in 1854 the first company was formed for the purpose of opening wells of natural oil in western Pennsylvania. When it was discovered how much oil was to be found there many wells were opened. It was discovered that petroleum could be refined and would then produce an oil very much like coal oil. This new oil was called kerosene and it became the chief product of the wells.

Oil wells are opened by drilling holes in the ground by means of machinery, till a sort of pocket is reached. Some wells are found about fifty feet below the surface, while others may be three or four thousand feet underground. When the oil pocket is first reached and opened the oil sometimes shoots high into the air unless some way has been arranged to prevent this. This gushing soon stops, however, and the oil must then be pumped out.

Petroleum, as it is taken from the wells, is mixed with many impurities. This must be refined or distilled in

order to produce in good condition all the numerous members of the petroleum family. One fortunate thing about the different members of this family is that they change to vapor at different temperatures. The petroleum is placed in a huge tank under which a fire



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BUSY OIL–WELL SCENE IN CALIFORNIA

can be built. With a small amount of heat the lightest member of the family changes into vapor and leaves its brothers and sisters. It passes off through a pipe and by being cooled can be condensed again into a liquid. This first product is called "petroleum ether" and is used by surgeons. Then, one by one, the other members of the family pass off as the heat becomes greater. Gasoline leaves soon after the ether; then

come benzine and — after that — the heavier brother, kerosene.

The thick, tarry substance which is left after the distilling is also valuable. It is purified and treated in various ways, and from it are produced oils which are used for lubricating axles, joints, and bearings of machinery, fuel oil which is used for heating purposes, and paraffin or asphalt. Some kinds of petroleum produce paraffin and others produce asphalt. Which of the two substances the petroleum yields depends on the location of the well from which it comes.

Petroleum is becoming more important every year, as we are constantly finding new uses for it. When automobiles were invented they at once demanded gasoline. Before this time gasoline had not been considered a very important product of petroleum, but the thirsty automobiles soon made it much more valuable than kerosene. Automobiles alone use millions of gallons of gasoline each year. Gasoline is also used in aeroplanes, motorcycles, tractors, submarines, and motor launches. Fuel oil is also coming into use more and more. Because it is clean and easy to carry, large steamships are now using it instead of coal. We are using petroleum so fast that before many years the supply in the United States will probably be exhausted. There are still great oil resources in Mexico, Russia, and some of the countries of western Asia. No one yet knows how much may be found in South America. The United States alone has used over 725 million barrels of petroleum in a single year.

FROM BANANA AND CACTUS PLANTS TO ROPE

SUPPOSE you were a savage, living in a world where there were no ropes, no cords, and no string. How would you catch the fish for your dinner? How would you tie the wild horse which you had caught, hoping to tame him so that he would work for you? How would you fasten the baby's bed to the tree branch, where the breezes might rock the child to sleep? You would soon discover the need of strings and ropes of some sort, and would find something from which you could make these useful articles.

That is just what happened so long ago that no one can tell when or where the first ropes were made. They were no doubt made of strips of bark or animal hide, of reeds or rushes, hair, tree roots, or perhaps long plant-fibres. Wherever people lived near water and could catch fish for food or venture out upon the sea in sail-boats, the need for ropes on the sails and cord for fishing led to the making of good strong cordage in very early times. People probably used single strings at first; then by experiment they learned that by twisting two or more strings together much greater strength resulted. The ancient Egyptians made excellent ropes of hemp, braided leather, palm fibres, a grass called papyrus, cotton, and probably of flax also.

The best ropes to-day are made of Manila hemp, which is really the strong fibre from a wild banana plant growing in the Philippine Islands. The plants are now cultivated there, and the raising and preparation

of the fibres for market is an important industry among the Filipinos. The fibres are contained in the leaves of the plants and are very tough and long, measuring from six to ten feet. The pulp is removed from the fibres by drawing the leaves under knives with rough edges. The fibres are hung in the sunshine to dry and are afterward tied in bunches and packed into huge bales ready to be shipped thousands of miles to the rope factories.

Much rope is also made of sisal hemp, a kind of cactus plant which grows chiefly in Mexico. The sisal fibres are not so strong as those of the Manila hemp and are not more than two to four feet long. These fibres are used chiefly for making twine for wheat-binders and other twines which will not see a great deal of hard wear. The leaves of the plants are cut by the natives, but the cleaning of the fibres is done by machinery, instead of by hand as in the Philippines. The fibres are then dried in the sun and are packed into heavy bales for shipping. Other materials used in rope-making are flax, jute, and cotton, though cotton is used chiefly for making string and cord rather than rope. Some fine fishlines are made of silk and hair.

All ropes and cords were made entirely by hand until 1820, when the first machine was invented for twisting the strands. By the old method the fibres were spun into yarns by a very interesting process. The fibres were first "hackled" or combed on a board set with sharp steel teeth. This straightened them and removed the short matted fibres. A workman would then wrap a large bunch of the fibres about his waist and, walking

backward from the spinning wheel, — which was turned by a boy and which operated the spindles to which the fibres were fastened, — he would spin or twist with each hand a fine yarn or thread, adding a new fibre whenever one was needed. The long walk down which he passed as he did the spinning was called a "rope-walk," a name still used in cordage factories. These yarns would then be twisted into strands. Two or three strands were twisted together to make common string or twine, several strings were required to form a cord, and three or more cords to form a rope. Thus ropes were made by a series of twistings, each twisting being done in the opposite direction from the one before, so that the rope would be firm, hard, and straight.

The twisting processes are now all done by machinery. In the modern rope-making factory the great bales of hemp are opened, the fibres are loosened and spread out, and are sprinkled with oil to soften them. They are hackled or combed by machinery and then pass to machines which lightly twist them and lay them end to end, in a long, loose sort of rope called a "sliver." The spinning machines then twist the slivers into yarns and wind them on to spools. Another machine twists the yarns into strands and the strands into cords or ropes. The strands which are to be used in ropes are usually passed through a bath of tar, so that they will not wear out so rapidly by rubbing against one another. The tar also protects the rope from moisture. If you have ever been on a steamship you will be sure to remember the tarry smell of its big ropes and cables.

RAINBOW COLORS FROM COAL

PRIMITIVE man learned very early to make cloth and clothing of wool, cotton, and other fibres. But as he looked about at the gay-colored flowers and at the birds and insects in their brilliant hues he must have felt dull and drab in his plain clothes. He no doubt began soon to try to find some way of getting for himself these gay colors with which Mother Nature was tempting him. Probably one of the first ideas which occurred to him was to crush the petals of bright-colored flowers. A little later he may have discovered that by soaking in water the leaves and roots and barks of certain plants and trees he could make stains or dyes of various colors.

Dyes made in this way from plants and trees are called vegetable dyes. The history of such dyes for coloring textile materials is very old. In the Bible we read about Joseph's coat of many colors, which proves that dyes were then in use. As Joseph's coat was rare enough to excite the envy of his brothers, such many-colored garments were probably rare.

Dyes have also been made for many hundreds of years from animals and insects. An old and very famous dye, called Tyrian purple, was made from the liquid found in a tiny sac in the head of a shellfish which lived in the Mediterranean Sea. This color was what we should now call a beautiful crimson. As it was rare and expensive it was used only for dyeing the robes of the Roman emperors and very high officials. Cochineal is another very old kind of dye, made by grinding into powder the dried bodies of little red insects which live

on the cactus plants of Mexico and some other lands. Indigo, a beautiful blue, is a famous vegetable dye made from the indigo plant of India. Until quite recent times India was the source of many of the world's best dyes.

By much experiment and by accidental discovery the world has gradually learned which plants to use for certain colors. Man has found that from the petals of the iris he can make purple; from the bark of the sassafras tree he can get orange and yellow; green can be made by mixing indigo with the juice of the golden-rod; and from brazilwood red and yellow dyes can be obtained.

Then during the last fifty years our modern magicians, the chemists, have been at work on dye-stuffs. They have discovered ways of imitating vegetable dyes so well that nowadays nearly all our dyes are made artificially. You would never guess that these artificial "aniline" dyes were made from common black coal.

When coal is burned in the open air, where it can have plenty of oxygen, parts of it pass off in smoke and in invisible gases and the only thing left at the end is a pile of ashes and clinkers. But if the coal is heated in a closed furnace or retort, where it can have no oxygen, it breaks up into several parts. Part of it passes off through a pipe in the form of gases; part remains as a heavy, burnable material called coke; and a black, sticky, ill-smelling substance called coal tar is also left. This coal tar has proved to be the source of some of the most wonderful substances which the chemist can make. By treating it in various ways

he can provide us with sweet-smelling perfumes, strong disinfectants, murderous explosives, curative drugs, and brilliant dyes which make the rainbow look as if it had been sadly faded by much rain and sunshine.

The making of coal-tar dyes has been greatly developed within recent years. A young English chemist accidentally produced the first aniline colors in 1856, while he was trying to make artificial quinine from coal tar. German chemists then spent years of time and millions of dollars experimenting with coal tar in an effort to find substitutes for the old, rather expensive vegetable dyes. New colors are still being made. Through the efforts of German, English, and American chemists more than nine hundred aniline dyes are being manufactured at the present time.

Coal-tar dyes are much cheaper than vegetable dyes and are more brilliant in color. The first ones made were apt to fade after a time, but improved methods of manufacture have almost cured them of this fault. Indigo has almost completely given way to aniline dyes, and the old Tyrian purple can now be made so cheaply from coal tar that a Roman emperor would feel quite ordinary in his royal robe. However, for some textiles the old vegetable-dyes are still preferred, particularly where soft, delicate shades are desired.

TAKING THE STARCH OUT OF PLANTS

STARCH, in addition to being an important part of many foods which we eat, is necessary in laundry work and in a great many manufacturing industries. It is used in cloth-making for stiffening and finishing or "sizing"

the materials; in wall-paper manufacture for much the same purpose; in the making of asbestos, soaps, adhesives, and cosmetics; and in many food-making industries. For home use, aside from its importance as a food, it is most important for laundry purposes.

Starch is to be found in its natural state in most plants, but especially in potatoes, sago, tapioca, rice, corn, and other cereals. There are comparatively few plants, however, which yield starch in large enough quantities for use in starch manufacture. Potatoes, corn, wheat, and rice are used chiefly, corn being used in America more than anything else.

The manufacture of starch is rather simple, as the starch granules or particles need only to be separated from the rest of the grain. In the manufacture of corn-starch the grain is soaked from two to four days in a weak solution of sulphur dioxide and water, in order to soften the grain husks. The swelled grains are then crushed between rollers over which water is flowing, and water washes the mass through sieves that strain out the pulp and husks. The milk-like fluid is purified by repeated straining, and the starch is finally allowed to settle in vats or tanks. It is then dried by gentle heat which makes it crumble to a fine powder. After these simple processes it is ready for packing.

The manufacture of starch from potatoes is also easy. The potatoes must first be thoroughly washed, as any dirt remaining on the skins lowers the grade of the starch. This washing takes place in wooden drums provided with openings through which the dirty water can pass out. Inside the drums are wire brushes or

bristles, which rub the potatoes together as the drums whirl around and help in the washing. When the potatoes are thoroughly cleaned they are cut into fine pieces in machines called "raspers." These are cylinders provided with knives or saws which assist in cutting the potatoes to a pulp as the cylinders revolve. Water is added as the rasping takes place, and the pulp is fed into a sifter or sieve. The sieve is a shaking table covered with gauze. The starch passes through the sieve with the water into settling tanks, and the remaining pulp can be pressed and dried for cattle food. The starch is allowed to settle and can then be dried.

Starch is made from rice, but by a slightly different process, because of the harder coat on the rice kernel. The grains are soaked for a day or two in a weak solution of caustic soda and water, which softens the outer coat or husk of the rice. The mass is then ground by rollers or stones, and the starch is separated by sieves. The settling and drying processes are much the same as for other kinds of starch. Rice starch is used mostly for laundry purposes.

FOUR KINDS OF BLUING

An article which is almost as valuable as soap in laundry use is bluing. If you have noticed that sometimes bluing comes in interesting little powdery blue balls and again in liquid form, perhaps it has occurred to you that bluing is not always made of the same thing.

There are really four different kinds of bluing. These vary slightly in their shades of blue, but all are used for

laundry purposes. These four blues have very big names: indigo, ultramarine, Prussian, and aniline.

The indigo blue is little used for laundry purposes nowadays, as it is made by a very complicated process

COLLECTING PINE SAP OR GUM FOR TURPENTINE
From *Turpentine*, by courtesy of the United States Department of Agriculture

from the indigo plant and is expensive. It does not dissolve in water, but its tiny particles hang suspended in the water, giving it the appearance of being blue. Indigo blue is sold either in lumps or in powder form.

Ultramarine is a more beautiful blue than indigo. It once was made of lapis lazuli stones, ground to a very fine powder. It is now prepared from chemicals and is

what we call a synthetic product, one made by artificial means. It is usually sold in solid form, either in blocks or in the pretty blue balls which you know.

Prussian blue is also a chemical product and is so named because it was first made in Berlin, the capital of Prussia. It always comes in liquid form and as it can be completely dissolved in water it is much liked for laundry purposes.

Aniline blue is the most interesting of all, as it is made from pitch-black coal tar. The process of its manufacture is complicated and hard to understand. A bit of the story of the coal-tar colors is told in the chapter about dyes. Aniline blue is used almost altogether in public laundries. It is very strong, so that only a little need be used at a time. It is inexpensive and has the advantage, since it is so strong, of making many different shades of blue, depending on the amount used. It comes in powder or crystal form, but is always dissolved in water before using. It is one of the best kinds of bluing, but is not used much in our homes because it is so strong. Clothes receiving too much of it are really dyed blue, and it is hard to make them look white again.

STORIES OF CLEANING DAYS

TURPENTINE, with its queer smell and its many uses, is one of the most interesting servants on clean-up day. It is a clear, colorless liquid which comes from certain kinds of pine trees. The sap is collected from the trees in two or three ways. The best method is by making holes in the bark and allowing the sap to drip into pails attached to the tree. This reminds us of the way maple

sap is collected in the maple groves of the northern United States. The older method of collecting turpentine was by chopping a cup-shaped cavity in the base of the tree and allowing the sap to flow into the cup. That method was very destructive to the tree, as it injured the inner bark, so that the tree lived only about four years after it was first cut.

The sap or crude turpentine, when collected, contains a great deal of sticky resin, which must be separated from the liquid. The sap is heated in kettles to such a high temperature that the turpentine oil boils and turns to steam. As it passes off, it is collected and condensed again to liquid by cooling. This process is called distillation. Turpentine is used extensively in making paints and polishes and is also very valuable in the laundry. It dissolves grease stains easily and is an excellent remover of paint stains.

Laundry day would tell you that among its many useful helpers are the water-softeners. Some water, you know, is called "hard" water. This hardness is due to the fact that certain kinds of minerals are dissolved in the water. These minerals cause a chemical action when soap is added to the water. They unite with some of the soap ingredients and form a white, curd-like mixture which does not dissolve in the water and which spoils the cleansing effects of the soap. Water-softeners are very useful, therefore, as they steal a march on the minerals in the water and coax them to form a compound which will not affect the soap when it is added. There are several kinds of water-softeners or washing-powders on the market. Most of them contain either

washing-soda (sodium carbonate), lye (caustic soda), or borax (sodium biborate). All of these sodium compounds unite with the hard mineral-salts in the water to form a new substance which does not interfere with the soap.

Cleaning day also finds among its servants the useful waxes and polishes which we use in our homes without giving them a thought. The busy little honey-bee is a valuable aid on cleaning day, although she has no intention of helping anyone but herself. The wax which the bee secretes and uses for making honeycomb is one of the most important ingredients in many floor and furniture polishes. Floor wax is usually a mixture of beeswax, turpentine, and paraffin. In furniture polishes you can recognize the familiar turpentine smell. In addition to this they generally contain beeswax and some sort of oil, such as linseed oil.

While thinking of useful polishes, we naturally remember our shoe polishes. There are as many recipes for shoe polishes as there are manufacturers engaged in making them — even more, for every manufacturer has his own secret recipes and he usually makes several kinds of polish. Most paste polishes contain either beeswax or carnauba wax. Carnauba wax is a substance obtained from the leaves of a palm tree which grows in Brazil. These leaves are thickly coated on both sides with a waxy substance. During six months of the year the leaves are cut twice each month, the older leaves being cut each time while the younger ones are left to mature. The cut leaves are spread out to dry, then are cut into strips and beaten, over a cloth, to

loosen the wax. This drops off in the form of scales or powder, and when it is melted with water it can be poured into moulds to harden. When this wax is mixed with paraffin, turpentine, beeswax, and some dye, such as lampblack or boneblack, it forms a good polish which will give a very high lustre when rubbed. Some liquid shoe-dressings contain molasses, stale beer, or a solution of castile soap to give the proper consistency. Dressings for suède shoes are usually a solution of wood alcohol with some dye. The alcohol will evaporate quickly and leave the color on the shoe.

A chemist could tell us interesting things about the removal of grease spots, ink, fruit, and grass stains, iron rust, and spots from spilled coffee, tea, and chocolate. There are many kinds of stain-removers and they all work in a queer way by what we call chemical action. Some of them are absorbents, and will take up grease and oil just as blotting paper drinks up spilled ink. Fuller's earth, talcum powder, and magnesia are all absorbent stain-removers. Other stain-removers dissolve the substance forming the spot, so that by rubbing the stain with the remover it will gradually disappear. Benzine, turpentine, ether, gasoline, and chloroform are all stain-removers of this sort. Spots of grease, paint, varnish, rubber, and resins can be removed in this way.

The most interesting stain-removers are those which actually form a new chemical substance with the material in the stain. The new substance must be colorless, so that it will no longer show on the cloth. Hence it is necessary to know something about chemis-

try in order always to use the correct remover. Ink and fruit stains are generally removed by this kind of process. The chemical helpers which are used have very big names, such as potassium permanganate, hydrogen peroxide, chlorinated lime, or sulphur dioxide.

PART V

IN THE BATHROOM

COMBS ARE MADE OF MANY THINGS

If you have ever seen the backbone of a large fish you can guess right away where man got his idea for the first comb. Among savage peoples even to-day fishbones are used for combing the hair. Some combs are still made with a row of teeth on each side and these probably look more like the early combs, which imitated fishbones, than those with only one row of teeth.

The use of combs for smoothing and arranging the hair is a very old custom. Greek and Roman women used combs of ivory and of boxwood, the hard wood of a small tree. Those combs had two rows of teeth; but among the Egyptians combs were in use with the teeth on one side only. According to history the early dwellers in England were much surprised by some of the habits of the Danes, a people from Europe who came to conquer England. The Danes were in the habit of combing their hair every day. This greatly amazed the people of England, who at that time were rather careless about their personal appearance. This story shows that the people of northern Europe used combs perhaps as early as the Greeks and Romans.

Combs to-day may be made of ivory, wood, bone,

rubber, celluloid, horn, tortoise shell, or metal. Tortoise-shell combs are made of the large, beautiful scales which cover the back of a kind of turtle which lives in the ocean. Horn combs are made from the horns of animals. It has been found that steer horns are the best of all. Celluloid is a material which man has learned to make in imitation of ivory. By its smell you know that it must be made partly of camphor. Other things besides camphor are used, but they all have big names which are hard to remember. The materials are worked together into a tough dough and usually rolled out into sheets, ready to harden and be cut up later into combs, piano keys, toys, dolls, and many other useful things. Ivory, as you probably know already, comes from the great white tusks of the elephant.

Combs from these various substances are all made by much the same process. They are always cut by machinery. Strips of the correct size for the combs are cut first and then the process of shaping the teeth takes place. This is done in two ways. By the older method the spaces between the teeth are cut out by means of saws. By this method all the material which is cut out is wasted and this seems a very expensive way to make combs. By the newer method the strips are placed in machines which are provided with knives. These knives cut the teeth of two combs at a time, so that the material between the teeth of one comb forms the teeth of the other comb. After the cutting is completed, a slight pull separates the two combs. The teeth are then polished and smoothed by means of

files or by being ground on wheels covered with sandpaper.

The horn which is used for combs comes from the middle part of the animal's horn. The tip is generally used for umbrella- or cane-handles, and the open end, where the horn was sawed from the animal's head, may be used for making buttons. As horns are round, they must be treated in a special way before straight combs can be cut from them. The horns must be cut into pieces, softened by heat, then rolled flat by machinery.

Rubber combs are made by pressing the rubber into moulds. Then by means of a process called "vulcanization" the moulded combs are treated with sulphur until they become very hard.

HOW TO KNOW A GOOD BRUSH

BRUSHES and brooms are closely related, since their uses are so often the same. We usually think of brushes, however, as being made of bristles or animals' hair, while brooms are generally made of vegetable fibre, such as broom corn.

No one knows just when brushes were invented, but it is quite probable that the Romans made common paint-brushes from bristles. Artists' brushes, which are made of finer material, such as camel's hair, were in use long before any other kind. They were probably invented by the Chinese two or three centuries before the birth of Christ. Hairbrushes did not come into use until much later, perhaps about the middle of the eighteenth century. We read very often that the

beautiful ladies of the olden time combed their hair, but they apparently had no brushes.

Many materials are used in brush-making nowadays, but the most important are bristles or hair of various animals, such as the hog, horse, camel, goat, squirrel, and bear. Feathers, rubber, steel wire, whalebone, and rushes are also used, as well as the fibres of certain plants and the roots of a kind of palm tree, which resemble horsehair.

The best brushes are made of the long bristles which grow on the back of the Russian wild boar. These bristles are stronger and stiffer than any other kind but are very expensive because they are becoming more rare all the time. Being too long to use as they grow, they are cut into different lengths for various purposes. The root-ends are generally used for hair- and tooth-brushes, and the other, softer ends for paint brushes. These flag ends, as they are called, resemble little brushes themselves, as they are split into many branches. They are thus well suited for paint brushes, because they hold the paint well.

Scrubbing brushes are usually made of vegetable fibres, such as rice roots and Mexican grass. Some vegetable fibres can be made to resemble bristles and are often used in hairbrushes. Tampico is a fibre from the leaves and flower stalks of a century plant which grows in Mexico. The leaves and stalks are cut and allowed to rot until the soft portions can be beaten out. The tougher fibres are then separated, dried, bleached, and stiffened, and when finished they so nearly resemble bristles that only an expert can tell

the difference. They do not wear so well as bristles, however, but lose their strength and stiffness when they have been washed a few times.

Brushes are, for the most part, still made by hand. The backs are usually of wood. In these, holes for the bristles are bored in even rows. For the cheaper grades of brushes the tufts or bunches of bristles are bound tightly with thread, dipped into glue or melted pitch, and twisted into the holes. The bristles soon pull out and the brushes do not wear long. For better grades the tufts are bound with wires, which are drawn through the holes and woven securely together. Covers are then glued to the backs, and the brushes are finished. Brushes made in this way are much better, as the bristles are held securely; but the covers on the backs may come loose in time.

The very best brush is one made with a solid back. For this kind, additional holes are bored lengthwise through the back, so as to connect the holes which are made for the bristles. The bristles are doubled over, so that the ends are together, and the loop-ends are forced into the holes. Wires or threads are drawn through the long holes, passing through these loops of bristles and holding them tight. The ends of the wires are then fastened with little plugs. As the best brushes are always made in this way, you can identify them by the row of little plugs in the end of the solid back.

FISHING FOR SPONGES

HAVE you ever wondered how a sponge is made? Man has never yet discovered how to make a real sponge,

though he can make a fairly good imitation from india rubber. Sponges are made in the bottom of the sea by queer little jelly-like animals. Many of these small animals live together in a community and bind themselves to one another by a sort of soft skeleton, which is the sponge as we know it. These animals attach themselves to rocks or to the sea bottom, and live on tiny particles of food and air found in sea water. The water flows into the sponge through the little holes in the skeleton and flows out again through the large holes which are so noticeable.

Thousands of years ago, perhaps in the days of the early Greeks, sponges were first known. Probably some were detached from their ocean bed and washed ashore on some beach. At any rate they came to be much used, and diving for sponges was a regular occupation among the Greeks.

Many kinds of sponges, some of which are very beautiful, are of no use to man. The chief source of the commercial sponge is in the eastern waters of the Mediterranean Sea, though sponges of a coarser and inferior grade are found in great quantities in the waters between Florida and the Bahama Islands.

As sponges grow in such an inconvenient place, fishing for them is often dangerous. They are obtained in three ways, by diving, by dredging, and by harpooning or hooking. The best method is by diving, as the sponges are much less apt to be injured when picked by the diver's own hands. In the Mediterranean Sea the profession of the diver is a very old one. Divers are trained from childhood and are able, without

special suits or apparatus, to go down to a depth of two hundred feet, remaining under water two, three, and even four minutes. To a certain extent the use of divers' suits is replacing the naked diving, as this enables a man to go much deeper and to remain under water as long as an hour.

SPECIAL SUIT FOR SPONGE DIVER WITH BREATHING-APPARATUS

From *Sponges*, by E. J. J. Cresswell, by courtesy of Isaac Pitman and Sons, Ltd., Publishers

The sponges are first located by means of the "water telescope," a deep bucket with a glass bottom, which, when immersed in the water, enables one to examine the ocean bed. The diver then sinks through the water, directing his course by means of a weight, gathers into his bag as many of the sponges as he can, then gives a signal on the rope, which is attached to one of his hands, that he is ready to be pulled up. The diver's profession is a dangerous one, for sharks and other sea monsters abound in warm ocean waters.

In waters too deep for diving the sponges are obtained by a dredge, which rakes the ocean bed and collects the sponges in a net. This

is much less satisfactory, as the dredge is destructive and breaks or injures many of the sponges.

Harpooning is done from small boats in fairly shallow waters. The harpoon is usually a three-pronged fork with a handle which can be lengthened to suit the depth of the water. The harpoons also often tear the sponges.

When sponges have been brought ashore the jelly-like little animals are squeezed out and the sponges are rinsed thoroughly. They are then thrown again into sea water, inside an enclosure built of boards. Here they are left until the water has washed them quite clean, being beaten occasionally with sticks to aid in forcing out all dirt and animal matter. The sponges are then dried and trimmed and are ready for the market.

Sponges grow rapidly, so that a sponge bed on the sea bottom is often ready with a fresh harvest within a year after the previous one. Little buds separate themselves from the old sponge, attach themselves to rocks, and soon have a large new colony flourishing, forming the spongy skeleton ready for next year's diving-season.

GLASS AND ITS MANY USES

If you write a list of all the articles you can think of which are made of glass, you will see how important a person the glass manufacturer is. There are windows, dishes, drinking cups, bottles, automobile lenses, microscope-, telescope-, and kodak-lenses, watch crystals, lamp globes, and hundreds of other necessary and

useful articles. Did you know that even the beautiful flaxen hair on many dolls is made of fine spun glass?

All these different kinds of glassware require different processes of manufacture and some slight variation in the materials used. We can tell here about only a few of these many kinds, for it would fill an entire book to tell the whole story.

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GLASS BLOWER MAKING BOTTLES

When you read above about window glass you learned something of the materials used in glassmaking, and how they are all boiled together at a terrific heat. Most of our glass dishes and bottles are made by machinery to-day, though the glass blower still plays his part in the industry. Glass-blowing machines are very complicated and have been so developed that practically all glass articles can be machine-made. A bottle-making machine can make as many as fifty thousand bottles in one day.

The bottles made by hand by the glass blower are the most interesting, because they seem like soap bubbles which forget to break. The blower takes only a little of the hot glass mixture on his blowpipe or "punty" — just enough for one bottle. This he blows until it is about half the size of the bottle desired, when he

places it in a bottle-shaped mould and blows again until the mould is filled. Bottles, after the blowing, must be annealed or tempered so that they may not break easily when exposed to heat. They are placed on large

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CUTTING DESIGNS IN GLASS ON EMERY WHEEL

pans and slowly passed through a tunnel-like oven, which gradually heats them almost to the melting-point and then slowly cools them. This slow cooling toughens or tempers the glass and makes it much less brittle.

Dishes are also made in moulds; but nowadays a mechanical iron plunger, something like a potato masher, presses the glass mixture into the form of the

mould, in place of the work formerly done by the glass blower. Cheap grades of cut glass are made in moulds also, the patterns being cut into the moulds. For finer grades the patterns are marked on the glass with chalk and are then ground out with chalk and emery wheels. The edges and surfaces are finally polished with a fine putty-powder until they glisten and sparkle like diamonds.

Glass beads are made by a very curious process. Two blowers form on their pipes slightly blown bubbles, which are opened and fastened together. Then, walking away from one another as they continue to blow, they form a long narrow tube, often very small in diameter. When this tube is fine enough it is cooled and broken up into strips. These strips are then cut into small bead-like pieces. These rough little pieces are mixed with finely ground sand and ashes, and are heated almost to the melting-point, being whirled around at a very rapid rate to keep them from sticking together. This smooths them and removes the rough edges. They are then washed thoroughly in water and are ready to be strung.

THE USEFUL CORK STOPPER

Cork stoppers, which are so common that we never think about them, are really more interesting than they appear to be. Cork is really wood, and is so light that it is almost impossible to make it sink in water.

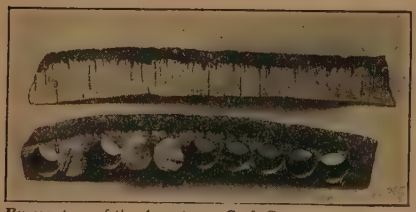
The cork tree is a kind of oak which grows chiefly in Portugal, but it also grows in Spain and some other

countries along the Mediterranean Sea. The cork we buy is the outer bark of this tree. The tree must grow steadily until it is about twenty years old, when it is ready for the first stripping. The trunk and the larger branches are completely stripped of this outer layer of bark. A ring is cut around the trunk at the base and another one just beneath the lower branches; a vertical cut joins these two rings, and the bark is then easily removed. Great care must be taken not to injure the inner skin, as the tree depends on that for life. The bark from the first stripping is so coarse and full of holes that it is worth very little on the market, but fortunately the tree at once begins to grow a new coat, and in eight or ten years is ready to be stripped again. The tree yields its best cork when it is about forty years old, but it will often go on growing new coverings of bark until it is at least a century old.

When the bark has been stripped off it is allowed to dry or "season" for a few weeks. Then it is boiled, to remove the tannic acid and to loosen the rough outer layer so that this may be easily scraped off. The cork is then packed in bales and is ready for shipment to all parts of the world.

Cork is used chiefly for stoppers, but has also many other uses. Stoppers are made almost entirely by machinery. The layers of bark are first put through a steam bath, so that they may be softened, ready for the scraping and cleaning process. A machine equipped with sharp knives cuts the layers into strips, which are sent to a machine that punches out the stoppers. The waste pieces are sent to smaller

machines for the cutting of smaller stoppers. If the corks are to be tapered, that is, made smaller at one end than the other, they must go through another machine for shaving at one end. As the final step, they are held against a sandpaper wheel until the surfaces are smooth.



By courtesy of the Armstrong Cork Company

CORKS PUNCHED FROM STRIPS OF BARK

There is still much waste after the cutting of the smaller stoppers. Some of this is used in the making of linoleum, which consists of cork powder mixed with linseed oil and spread on canvas. "Spanish black," a very fine color for paint, is made from the burning or carbonizing of cork waste. Cork board, and many other articles of commerce, is also made from cork waste.

Cork is used in the manufacture of life-saving belts because it is so much lighter than water that it can even help hold up a man's body (which is heavier than water) and keep it from sinking. Floats or buoys for fish nets are made from cork for the same reason. Because it is so light it is used for making artificial limbs. Because it deadens sound it is used as a floor-covering in many hospitals and other public buildings. Because it resists heat it is used as a lining for the helmets worn by people who work in hot, tropical countries. It is used for shoe soles, for the cork paper used on cigarette tips, and in Portugal is even used for making furniture.

Centuries ago many ancient peoples, the Egyptians, Romans, and Greeks, had discovered its value and used it in many ways.

STEALING NATURE'S SCENT

THE use of perfumes and sweet scents is almost as old as the art of dress itself. We find many references in ancient records to incense and fragrant spices. The rarest and most acceptable gift, even for a great king, was a bottle of sweet ointment or fragrant oils. The earliest perfumes were natural substances, such as myrrh, frankincense, cassia, and other dry gums. The art of distilling fragrant water from leaves and flowers was not discovered until sometime during the tenth century.

The delicate scents which are used in our perfumes to-day come from all over the world. Bulgaria, Turkey, Siberia, China, France, Algeria, Java, Thibet, and many other lands yield spices, flowers, or fragrant seeds and grasses which go into the manufacture of perfumes. The chief centre of perfume manufacturing is in southern France, in the sunny provinces bordering on the Mediterranean. Millions and millions of flower blossoms are grown there every year to make the delicate perfumes for which France is noted.

Perfumes are of three kinds. Some are made from plants — either from blossoms, from seeds, or from sweet gums; others come from some part of an animal; some are made synthetically or artificially.

The fragrant oils extracted from blossoms for the making of perfumes are called essential oils. Many

of these are extremely volatile, that is, they evaporate very quickly, and the process of extracting the oil from the flowers is therefore a very particular one. The less volatile oils are extracted by distillation. The blossoms are boiled in water, the oils passing off with the steam and being later condensed into liquid oils.

The more volatile oils are extracted by processes which are based on the tendency of fats to absorb odors. By one process the blossoms are mixed slowly in large vats of melted beef or pork fat, the fat absorbing the odor. The mixture is stirred from twelve to forty-eight hours, or until all the perfume from the flowers has been absorbed. The fat is then strained off and a fresh lot of flowers added. This process is repeated until the fat is sufficiently fragrant. This perfumed fat is called pomade. For the making of liquid perfumes the fat is washed with alcohol, and as this has a stronger attraction for the odor than the fat has, it absorbs all the scent and the resulting mixture is a liquid perfume.

One of the rarest of essential oils is attar of roses. Into the making of one pound of this oil over three million rose blossoms must go.

Animal perfume-substances are of several kinds. The most used are musk and ambergris. Musk is a substance taken from the musk deer of Siberia, Thibet, and China. Ambergris is a cast-off secretion from the sperm whale and is found only in warm ocean waters. Most animal perfumes have an extremely disagreeable smell in their pure state, but a small amount used with other perfumes gives a delightful odor, and also serves to make oils less volatile.

Artificial perfumes are among the most interesting things which modern chemists have learned to make. From various substances, such as coal tar, they have discovered how to make odors which so nearly resemble natural ones that many people can detect no difference at all. Many violet perfumes now on the market have in them no real violets at all. These artificial perfumes are cheaper than the natural ones and the time will probably come when the chemist can so exactly duplicate natural odors that no difference at all can be noticed.

The perfumer's art is a very fine one and requires much skill and knowledge. Our modern perfumes are the result of much experiment. The requirements of a good perfume illustrate how careful the manufacturer must be in combining his materials. The odor must be lasting, but yet very delicate. All the materials used must evaporate with the same rapidity, otherwise the perfume would change in quality and odor as it evaporated. The slightest change in the amounts of various ingredients used will often completely alter the odor of the perfume. Hence the utmost care must be used in measuring and mixing the materials.

PART VI

IN THE DINING–ROOM

THE DISHES ON OUR TABLES

DISHES of some kind have been in use no one knows how many thousands of years. Just as soon as primitive man ceased wandering about like the animals and began to settle down and live in some fixed spot, he discovered the need for articles of some sort in which to keep and cook his food. No one country can claim to have invented pottery; primitive people all over the world discovered the secret when necessity drove them to it.

The simplest kinds of dishes, such as are found among savages, are easy to make. Perhaps you have even made dishes yourself. Clay, when wet with water, becomes doughy and can be moulded into the shape of a plate, a bowl, or a cup. When dried in the sunshine it will hold its shape well unless left out in the rain or crushed in some way. But if baked in an oven with great heat it becomes much harder and tougher and is no longer affected by rain or other moisture. The discovery of this simple secret about clay has led to the making of all the beautiful porcelains, chinaware, and pottery which people in different countries have learned to produce.

The next important advance was the invention of

the revolving table or wheel which has been used by potters or dish-makers all over the world. This is a flat circular board, attached to a sort of treadle which,

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POTTERS CREATING BEAUTIFUL JUGS ON POTTER'S WHEEL IN SICILY

when worked by the foot, will make the wheel whirl around. The earliest wheels were still more simple and were turned by hand. Some of the modern potter's wheels are turned by machinery. China and Egypt both claim to have invented the potter's wheel

first, but no one can settle that matter. The fact that we call our nicest tableware "china" shows where the art of making it long ago reached perfection. The early Egyptians believed that the wheel was a gift from their gods; they even thought that the god who created the world made the first man on a potter's wheel.

The work of the potter at his wheel seems so much like magic that it is no wonder those early people believed the gods had something to do with it. The potter sets a lump of soft clay upon the wheel and makes it spin swiftly round and round while he gently shapes the stuff with his hands. The dull-looking lump seems alive. With his skillful fingers the potter can make the clay rise into a tall, graceful vase or spread out into a beautiful bowl. By what seems the merest touch of his finger-tips the top of the whirling vase curves over into a rim. By holding the tip of one finger lightly against the moving side he can form a delicate, even groove around the vase. When he has worked the clay into just the shape he desires, he cuts it from the wheel by means of a wire, and sets it aside to dry.

The earliest potters used the ordinary clay which they found in fields. But as pottery-making became more of an art they learned that clay alone did not make the best pottery. By mixing with it flint and a mineral called feldspar a better material is secured. By using different amounts of these various substances different kinds of pottery are obtained. For this reason manufacturers of chinaware now keep their formulas secret, so that it is difficult to make an imitation of the most beautiful pottery.

Ages ago the Chinese discovered a way of melting certain ground-up minerals with clay to make porcelain. Porcelain differs from other kinds of pottery in being almost like glass all through, and in being so finely made that it will ring when tapped in the right way. The Chinese hundreds of years ago made the most beautiful porcelain which the world has ever seen. No one has been able to duplicate it. But in trying to learn the secret of their wonderful porcelain the people of Europe discovered for themselves new ways of mixing their own materials, so that new kinds of porcelain resulted, which some people consider almost as beautiful as that made by the Chinese.

The preparation of clay and other substances for making pottery requires great care and skill. The mixture must be ground so fine that, when mixed with water, it looks like cream. It is put into a beating machine or "plunger" which has great paddles for beating. The coarser sand and tiny pebbles drop to the bottom. In some processes magnets are used to take out any bits of iron which may be in the clay, for iron causes brown or yellow spots in the finished ware. Usually some kind of bleaching chemical is used to make the clay whiter. Sometimes the mixture is strained through fine silk sieves and then thoroughly beaten again. The prepared mixture is called "slip." If the dishes are to be made on the potter's wheel the surplus water is strained out through canvas bags and a dough-like substance is ready for the potter.

The use of the old-time potter's wheel is now decreasing, giving place to quicker methods. A great many

dishes are now made in moulds. The inside of the mould is given the shape of the dish desired, the mould being in two or more parts. The clay is pressed into the mould, either by hand or by machinery, and when it is dry the mould is taken off in pieces, so that the dish itself may not break. The thinnest kinds of china are made in plaster-of-Paris moulds. The slip is poured into the moulds, and as plaster of Paris is quite full of pores it absorbs the surplus water and the clay settles over the inside of the mould. When a thick enough layer has collected, the rest of the slip is poured out, and the layer is allowed to dry. The mould is then taken off and the dish is ready for the next process. Whenever a handle is wanted on a dish it is formed separately and fastened on with a bit of slip.

After dishes have been moulded, no matter which process has been used, they must be fired. They are placed inside a huge brick oven or kiln and the door of the oven is tightly sealed. Fires are lighted and a terrific heat is created. The dishes are left in the oven in this very high temperature for two, three, or even four days, and are not removed until the oven has cooled, which takes two or three days longer.

At this stage the pottery is called biscuit-ware. The dishes are dull and rough; they do not have the shiny surface or glaze which makes them beautiful. Neither do they have any decorations or colors on them. These can be put on now or after the dishes have been glazed. The decorations can be painted on with a brush or they can be transferred from tissue paper, as we sometimes decorate Easter eggs.

For the smooth finish, the dishes are dipped into a mixture called glaze, which is composed of the same materials as are used for making glass. These materials are first melted and cooled in sheets, then thoroughly ground until they look like flour. This powder is then boiled with water to form a clear liquid. The dishes are dipped into this clear solution very skillfully, so as not to leave fingerprints, and are then placed again in the kiln. This time everything must be done most carefully so that no dish shall touch another, in order not to leave a mark. If you notice very cheap dishes, you will find spots which have not been completely covered by the glaze. They may be finger-marks or places where one dish was carelessly allowed to rest against another. For the glazing, the heat in the kiln does not have to be so great as for the original firing. About fourteen hours are all that are necessary to fix the glaze on the body of the dish and make it look like a layer of thin glass over the surface. If the decorating is put on after the glaze, the dishes must be fired again in order to burn the new color thoroughly into the glaze. Colored potteries may be given red, yellow, or blue coats by putting a dye into the glaze, or the color may be painted over the glaze.

Under the name of pottery are included all kinds of articles made of clay and baked in a kiln. Coarse drain-pipes and common red flowerpots are first cousins to the beautiful Rookwood and Grueby potteries, and they are even very closely related to the rare old porcelain vases from the hands of the ancient Chinese potters.

KNIVES AND FORKS INSTEAD OF FINGERS

THE custom of using knives and forks at the table is not very old. The easiest and simplest way to eat is the one you probably use between meals — the one we all used when we were quite small and knew no better. Primitive man naturally used his fingers. When he began to make knives or sharp tools of stone and flint it did not occur to him to improve upon his simple method of tearing up his food. It is only as man has become more and more civilized that he has learned to keep his fingers clean while at the table by using knives and forks.

Knives, for use as weapons and cutting tools, have a very ancient history. Following the stone and flint knives or hatchets of the earliest times, knives were made of bronze and iron. They were in wide use among the Romans and Greeks. The Romans probably invented the pocket knife with the blade folded into a groove in the handle. But those people used knives only for cutting food before it was placed on the table. Just like their primitive ancestors, they used their fingers for carrying food to their mouths. Later on, during the Middle Ages, each person carried a knife about with him in his stocking or his belt. If he wished to use it at the table he did so, even carrying the food to his mouth with his knife.

Spoons are almost as old as knives. They were probably used at the table much sooner than knives, because it is difficult to eat liquid foods with the fingers. The earliest spoons were probably shells. In ancient

Egypt spoons were made of wood, stone, and ivory, and among the Greeks and Romans they were also made of bronze and silver. During the Middle Ages they were made of wood, horn, tin, and pewter, while some wealthy nobles had spoons of silver.

Forks did not come into use until the seventeenth century. For a long time they were considered very queer and people who used them were ridiculed. In some of the convents it was even considered a sin to use them, since God had given fingers with which to handle our food. Forks were at first made with only two prongs. It was not until 1682 that four-pronged forks came into use. In many parts of the world forks are not used to-day. In China and Japan, for instance, chopsticks take the place of forks.

Not all of us can afford to have solid-silver tableware in our homes. Solid silver is generally mixed with a little copper to make it sufficiently hard, as it would otherwise bend too easily, and lose its shape. The old silver-workers or silversmiths did most of their work by hand, hammering and beating the metal into the most exquisite shapes and designs with the aid of very simple tools. Nowadays complicated machinery is used for much of the solid-silver work, though the finest pieces are still hammered into shape by hand.

Since plated silverware has come into use it is possible for most people to own it. It was first called Sheffield plate because the process of plating was invented in Sheffield, England. It consisted of attaching a silver layer to a copper base or inside shell by means of heat

and pressure. Later it was discovered that by means of electricity a metal such as steel or copper could be covered or coated with silver by dipping it into a bath or solution of silver. This process is called electro-plating. For knives and forks steel is generally used as the base, while for spoons German silver is used. German silver is a manufactured metal or alloy, made by combining copper, zinc, and nickel. Plated silver is called single, double, or triple plate, depending on the number of baths it receives in the silver solution. The metal bases for plated ware are cut out of sheets of metal by means of sharp dies or stamps.

The finest, sharpest knives are made of hard steel, as this can be ground and sharpened to a thin edge. But because silver is so beautiful it is used more for tableware to-day than steel. The cheaper grades of steel knives, both table and pocket knives, are cut and ground by machinery, but the best ones are made almost entirely by hand and receive a high degree of skill and care in their making. The very hardest steel is used. It is hammered into bars and rolled into thin, narrow strips and is then ready for the blade-maker. He cuts from the strip the proper length, heats it red-hot over a coke fire, then hammers the blade to a thin, fine edge. After many other processes, including hardening, tempering by slow heating and cooling, more grinding and polishing, the blade is given to the cutler, who polishes and finishes the handle and puts the blade into it. After this the blade is again whetted or ground on a grindstone, is polished once more, and is then ready for the market. Pocket

knives require more labor in the making, as they must have a keener, sharper edge than table knives.

HOW GREAT-GRANDMOTHER LIGHTED HER HOME

CANDLES have been used by man for a very long time. They were even used in Roman days and were made of wax or tallow just as they are to-day. They are mentioned in the Bible, also; but those candles were probably a kind of lamp, for it is known that the lights in the seven-branched candlestick were fed by oil. Our great-grandmothers, back in Colonial days, lighted their houses largely with candles and they made the candles in their own homes.

Many of these great-grandmother candles were made from bayberries, which are very rich in fat and which grow on wax-myrtle shrubs. Others were made of tallow from beef or mutton fat. These candles were mostly made by the "dipping" method. The wicking was bought ready-made and wicks were cut twice the length of the candle. These lengths were doubled over a horizontal bar or stick, then twisted together. Several wicks would be hung on one such stick. The tallow or fat was melted in a large basin and the hanging wicks were dipped into the tallow. After cooling they would be dipped again, and a new layer of tallow would thus be added to each wick. This process was repeated until the candles were as thick as desired.

Nowadays candles are of course manufactured commercially and we can no longer see our grandmothers making pretty lights for their homes. They are made

of various kinds of fats — tallow from beef or mutton; the solid part of palm and coconut oils; wax; whale oil; paraffin, which is a white, solid substance obtained in the distilling of petroleum.

Candles are made in three different ways; by dipping, moulding, or rolling. The dipping process is much the same as in old times, and dipped candles are still made in large quantities for special uses.

The moulding process is much more common to-day and is done chiefly by machinery. By this process the material is shaped in hollow metal cylinders just the shape and size of the candle to be made. These cylinders are open at both ends, but the upper end is covered with a little cap which has a hole through which the wick can pass. The moulds are fixed in a trough, heads down. The wicks are drawn through by wire and held firmly in the centre of each cylinder. The melted tallow is then poured into the trough and fills all the cylinders. After cooling for about twenty hours the candles are hardened and can be removed from the moulds.

The rolling process is generally used for wax candles. The wicks are hung from a ring and the melted wax is poured over them repeatedly, allowing them to cool between each pouring. When the candles are thick enough, and while they are still warm, they are rolled on a wet table by means of a flat board. This makes them perfectly round and they are then ready for cooling and storage.

Have you ever heard of candle snuffers? Those were scissors made specially for cutting off the end of the

candle wick after it had burned and become charred. Unless cut off, the wick would soon smoke and produce a bad smell. But nowadays snuffers are no longer necessary, because of an improvement in the wicks. The wicking is now plaited and so made that it has a tendency to curl outward as it burns. In this way the wick meets additional supplies of oxygen in the air around the borders of the flame, and is more completely burned. Its carbon unites with the oxygen to form a new substance, a gas which passes off into the air, leaving no troublesome smoky odor behind.

HARNESSING THE SPARKS OF HEAVEN

When Aladdin rubbed his lamp in the long ago and produced wonders marvelous to behold, he did not dream of the genii of science to-day, whose giant-like accomplishments dwarf all the stories of his efforts. The history of our new Aladdins of electricity outshines all the tales of the Arabian Nights if we have eyes really to see the wonders about us.

The flash of sparks from heaven in times of thunderstorm brought fear into the hearts of men in ages past; in the course of time they learned that similar sparks of power are to be obtained from the earth all about us, capable of becoming, under proper conditions, mysterious servants, lighting our homes, sweeping our floors, cooking our meals, running our sewing and washing machines, turning our summer fans, ringing our doorbells, driving our motor and trolley cars, and flashing messages by wire, wireless, and radio to all parts of the wide world. Furthermore, when treated in a friendly

way, they may be bought by measure as we buy water or oil, and turned on or off as we regulate gas.

Electricity, like water in a basin or tank, may be quiet and restful, or it may be in motion and flow in a current, as water in a pipe. When at rest it is "static," when in motion it is "current" electricity. Doubtless you have made static electricity by friction, by rubbing a fountain-pen cap on your sleeve, which when slightly electrified will pick up very small bits of paper; by rubbing glass on silk for the same purpose; or by shuffling your feet on the carpet and touching some other object to see or hear the spark. Perhaps you have even lit a gas flame by a finger-tip spark.

Current electricity comes or flows from batteries and dynamos. Doorbells and toy electric machines are run from dry-cell batteries. Electric automobiles receive their power from much larger and stronger "wet" or storage batteries, made from special metal plates and an acid which starts the generation and flow of current electricity from the plates through their connecting wires. Great dynamo machines in the electric power-houses generate or create the electricity which flows over the wires to light the lamp bulbs in our homes. When you press the button you simply start or stop the flow, connecting or disconnecting the circuit. It is quite simple when you think of it in that way.

When the current flows through the small network of fine wires in the lamp bulb, it meets so much resistance that the wires become white hot, producing the incandescent light. All the electrical heating appli-

ances or devices in the home, such as the toaster, coffee-percolator, hot plate, heating pad and curling iron, electric iron and heater, produce heat in much the same way when the current is turned on and passes through a coil of wire that offers resistance. You can easily see this struggle of wire against current in the toaster and heater. If the current becomes too strong, there is danger of overheating and of fire unless there is a fuse-box in the house. Each line or circuit of wire should be protected with a fuse made of a short bit of soft wire which readily melts when the danger-point approaches, thus breaking the connection and stopping the current.

It is interesting to watch an electric coffee-percolator at work. The heat is supplied by a coil of wire at the bottom of the pot. Through the cup holding the ground coffee above the water a small tube passes from the bottom to the top of the pot. A small amount of water stands in this tube and when the heat at the bottom of the pot turns some of the lower water into steam the water in the tube is forced to the top by the energy of the expanding steam, which is lighter than water. From the top of the tube the water falls on the coffee grounds and seeps slowly back into the pot through the holes in the cup. In the meantime more steam shoots more and more hot water up the tube like a busy little elevator.

One of the odd things about electricity is the magnetic force or power surrounding a wire carrying an electric current. Wrap an electric wire about a piece of soft iron and turn the current on. The iron immediately

becomes a magnet, but as quickly loses its power when the current is turned off. Your electric doorbell rings when you press the button. The button starts the current through the bell, causing the little clapper in the bell to fly back and forth between a spring and a piece of iron made into a magnet by the electricity. As it flies it hits the gong, but it stops when you take your finger away from the button.

Electric fans, vacuum cleaners, sewing machines, and washing machines are run by electric motors which operate much like the small doorbell. They change electric current into motion or motive power in a marvelous way. These and so many other amazing wonders and discoveries in electricity have done much to change our ways of living. Even Michael Faraday, "the greatest experimenter," and Benjamin Franklin, "the first American electrician," would be dumfounded at the results of their efforts, were they living to-day. Mysterious forces, marvelous energy, and yet undiscovered secrets await the search of new Aladdins in the electrical world.

GIRDLING THE EARTH WITH THE HUMAN VOICE

SHORTLY after the close of the Civil War a young Scotchman came to America in search of health and fortune. He was a teacher of deaf-mutes, as had been his father, who invented a system of visible speech or teaching speech by lip-movement. Naturally this young man was much interested in the human voice and in methods of carrying and reproducing sound.

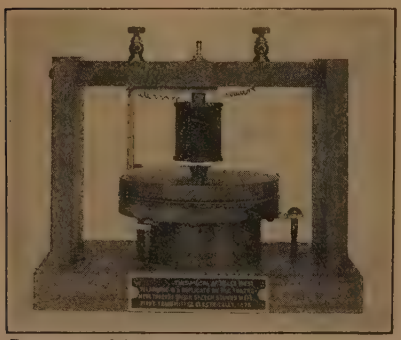
Many years before coming here he and his brother had made a talking machine which repeated the word, "Mam-ma."

His highest ambition was to invent a musical telegraph. On this idea he worked long and hard after his teaching-hours and late into the night in his stuffy little shop in Boston. Then a new thought came to him. "If I can make a deaf-mute talk," he said, "I can make iron talk. Why should not a vibrating disk set an electrified wire into vibration?" Could he make a thin piece of iron vibrate like the drum in the human ear? Could he, by electric current running along a wire, vibrate another small disk and there repeat the sound as received at the beginning?

This young Scotchman was Alexander Graham Bell. His assistant, who shared in his work and honor, was Thomas A. Watson. These two toiled in poverty for many months, experimenting with countless devices. They were familiar with electric bells and with the telegraph which carries its messages by dots and dashes. They hoped to perfect an instrument which would catch the spoken word and carry it silently like magic to a distant person who could instantly receive the message and answer in turn.

In 1876, partly by accident, these two men made an instrument which transmitted or carried the sounds of their voices; and in great excitement Bell called into the receiver: "Mr. Watson, please come here, I want you." Soon this discovery became one of the greatest in all history. Bell hastened to exhibit it at the great Centennial Exposition in Philadelphia. At first no

notice was taken of it; even the judges almost passed it by, for it seemed only a toy. Fortunately the young Emperor of Brazil, Don Pedro, followed close behind the judges and they watched him exchange messages with Bell over the telephone. When Bell spoke, the Emperor dropped the instrument and cried: "It talks — it talks!" The event was a significant occasion. In a moment Bell's telephone became the most marvelous invention at the Exposition and the inventor suddenly became famous.



By courtesy of the American Telephone and Telegraph Company

MODEL OF BELL'S FIRST TELEPHONE

Later he won fortune, in addition to fame, when the great Bell Telephone Company was formed and communication was established between cities. Bell obtained the patent upon his invention on March 7, 1876, and it has been called the most valuable single patent ever issued. On the same day another inventor, Elisha Gray, applied for a similar patent, but later it was decided that Bell was the rightful inventor.

Within a few years other telephone companies were organized, and now there are many thousands, most of them connected with the Bell system. So great has been the growth of this business that at present there are more than fifteen million telephones in America,

which means that there is a telephone for every seven people in our nation. Far more than half the tele-

By courtesy of the American Telephone and Telegraph Company

OPERATOR CONNECTING CALLS AT CENTRAL SWITCHBOARD

phones in the world are to be found in the United States. The use of the telephone has become a national habit, a national necessity. In business life it

gives service in countless ways. In the home and school it is a daily convenience. In hospitals and police and fire departments it brings aid and relief in emergencies. It has transformed methods of conducting business. It has brought families, farming communities, cities, states, and nations closer together, for men may now speak together though they are hundreds of miles apart. Perhaps some day an invention will make it possible to see the speaker by telephone, for pictures have already been sent long distances over telephone wires.

Constant study by experts in the telephone companies develops new uses and new inventions. The telephone instrument in your home is not so simple as it appears, for it is made of more than two hundred parts, which are planned, produced, and put together with extreme care and accuracy. Scientific men are busy making special studies of sound, particularly of speech and hearing, and devising new inventions of equipment for the development of the art of electrical communication. Unusual attention is now being given to the improvement of the wireless telephone or radio, which a few years ago came in as the small brother of the telephone, and now with its electrical waves leaps through the air from ship to shore and nation to nation.

The mysteries produced by the power of electricity and the magic of its instruments seem beyond belief, yet the half has not yet been told. The Greeks sent messages by runners on foot; the Indians, by smoke signals; the African natives, by beating drums; but to-day the human voice itself travels across land and sea with the speed of a flash of lightning.

PART VII

IN THE LIVING-ROOM

THE RUG-MAKER'S CRAFT

RUGS and carpets were first made in the East by people living in Persia, Turkey, India, and China. They developed the craft of rug-making into such a beautiful art that their work has never been surpassed. Oriental or Eastern rugs are still considered the most beautiful in the world, although many of the secrets of early rug-makers have been lost. Certain rug-patterns usually belonged to certain families. Each family had its own designs and its own secrets for making dyes. In some parts of the East descendants of those families are still rug-makers and are using the same designs as those used by their forefathers. Oriental rugs are made entirely by hand, and for this reason the worker must be a person of great patience. To make a really beautiful rug he must care more for the beauty he is creating than for the money he can get for the rug when it is finished.

The surface of these rugs is of wool, sometimes mixed with silk or camel's hair. They are made on a woven foundation which has warp and woof like any woven cloth, and a pile or nap such as velvet has. The foundation may be of wool but it is usually of linen or hemp.

The rug-maker works in front of a frame or loom on which he stretches the threads of the warp in even parallel rows. The face of the rug, or the pile, is formed of the ends of knots which are tied, one at a time, to the warp threads. After each row of knots a row of woof or crosswise thread is woven in. The finest Oriental rugs have sometimes seven hundred of these little knots to one square inch. No wonder some workmen spend several months in weaving a single fine rug.

The old rug-makers made their own dyes from animal or vegetable substances. Those dyes have never been equaled. The yarns were colored long before the rug was woven, and were often hung out in the sun and rain for weeks after the dyeing. This softened the colors and made them so much a part of the yarns that they would not fade further. To-day even Oriental rug-makers use a great many artificial dyes made from chemicals.

With the exception of Oriental rugs most carpets and rugs are now made by machinery. They are composed of warp and woof threads, the woof sometimes forming a loop-shaped pile, as in Brussels carpets. The work is done by machines similar to those used for weaving cloth. They go by many different names, — ingrain, Brussels, Axminster, velvet, Wilton, chenille, — and each kind differs either in the materials used or in the way it is woven. The yarns for machine-made carpets are usually dyed before the weaving, but a few kinds are printed with a colored design after being woven.

Rag rugs and carpets have been made in America

since Colonial times. For these the warp threads are made of strong cord or twine and the woof is formed from strips of old clothing. They can be made very beautiful if care is used in combining colors.

Many linoleum rugs are made in the United States. As we learned when we read about cork, these are made by spreading on canvas or other coarse cloth a mixture of linseed oil and ground cork.

Carpets and rugs in large quantities are also made of grass or vegetable fibres of various kinds. These are called matting or fibre rugs and are made by weaving on looms.

The United States makes and uses more carpets than any other country in the world. Philadelphia is the leading city for the manufacture of carpets and rugs. Many Oriental rugs are brought to this country and sold, and as they are made slowly by hand, they are much more valuable than the products of machinery.

FURNITURE THE BADGE OF CIVILIZATION

PRIMITIVE man often lived in caves and probably wandered about from place to place. You can imagine what a nuisance furniture would have been to him! When he was ready to move he wanted to take with him only such things as he could easily carry in his arms or on his back. Chairs, beds, and tables would have had to stay behind for the next renter.

Only as man became a little more civilized did he even think of covering the ground of his hut or cave with leaves or skins, still less with woven blankets. He sat on the ground, slept on the ground, and ate on

the ground. The first attempts at furniture were skins and other rugs to make the ground a little softer. Among some of the civilized peoples of the East rugs, cushions, and curtains are still used more than anything else in house-furnishing. But in most countries of the world man began to make furniture of some sort as soon as he settled down to live in houses made with floors.

The ancient Egyptians were a highly civilized people. They knew how to do some clever things which no one in the world has been able to do since. Among these people woodworking was developed to a fine art and we find that they were skilled in making many pieces of furniture. Their chairs were sometimes even upholstered and cushioned with seats of leather, linen, or woven rushes. One of the oldest pieces of furniture now existing is a quaint wooden throne which belonged to an Egyptian queen. This is now stored in a famous museum in England. It is over three thousand years old.

The Romans and the Greeks made very beautiful furniture. They had couches, chairs, and tables of elaborate design. Some of their furniture was decorated with ivory, gold, or silver, and occasionally was made splendid with precious stones. But among all those ancient peoples furniture was still rare and was to be found only in palaces and in homes of the very wealthy. Common people had almost no furniture other than rugs on which to sleep.

For several hundred years after the Romans lost their power in Europe civilization almost died out.

During this time furniture was crude and scarce. Even in the castles of the great nobles people sat on uncomfortable benches, and the tables in their banqueting halls were made of rough boards laid on trestles or rude frames. But during the fourteenth and fifteenth centuries craftsmen in many countries began to be more interested in woodwork and attempted to make furniture more comfortable and beautiful. The Italian

CHIPPENDALE IN HIS WORKSHOP WITH AN APPRENTICE
From *Compton's Pictured Encyclopedia*, by courtesy of F. E. Compton and Company

cities, Florence, Milan, Rome, and Venice, became the first great centres of furniture-making. During the seventeenth and eighteenth centuries France and England developed the art of furniture-making to a very high degree. The beautiful designs worked out by some of their leading craftsmen have never since been surpassed, and they continue to furnish models and patterns for modern manufacturers. The elegant styles of French furniture are now spoken of by the names of the kings under whom the craftsmen worked.

For instance, we speak of the style of Louis XIV or of Louis XV. In England the craftsmen left their own names to the styles of furniture they designed, so that when we speak of Chippendale, Sheraton, or Heppelwhite furniture we remember the men who originated such designs.

MACHINE FOR CUTTING SEVERAL FURNITURE LEGS AT ONCE

From *Compton's Pictured Encyclopedia*, by courtesy of F. E. Compton and Company

Most furniture is produced nowadays by machinery, but machines cannot make such solid, durable, beautifully finished furniture as that of the old craftsmen. Woodworking machinery has been perfected so that it can imitate hand carving, and many beautiful effects are possible. There are machines for sawing, smoothing, shaping, and decorating the wood, and even amazing machines which spray furniture with varnish or paint.

When the separate parts of a piece of furniture are ready, they are put together with wooden pegs, screws, and glue and are then held tightly between clamps or presses until the glue is quite dry.

SPRAYING VARNISH IN A MODERN FURNITURE FACTORY
From *Compton's Picture Encyclopedia*, by courtesy of F. E. Compton and Company

The United States now manufactures more furniture than any other country in the world. It was in our country that the rocking chair was invented and such pieces of combination furniture as the folding bed and the chiffonier were first made.

Many kinds of wood are used for furniture-making, but the most popular are probably mahogany, cherry, maple, birch, and walnut. The fibre furniture which is sold so much to-day is made of paper. The paper may be shaped into strands by heavy pressure or twisted over wires, and then the weaving is done by hand.

THE EMBLEM OF MAN'S VANITY

Ever since primitive man first saw his reflection in a pool of water, he has no doubt possessed vanity enough to enjoy looking at himself. Can you not picture to yourself how savage women of all countries seek out still pools of water and there, enjoying the reflections which they see, bedeck themselves with beads and ornaments and arrange their hair? From an early period in man's history, when his only mirrors were to be found in lakes and streams, we have the beautiful legend of Narcissus. You remember how he first saw himself reflected in a quiet spring and was so pleased with the graceful creature whom he saw there and thought to be a water sprite, that he fell in love with himself!

The first real mirrors were made of brightly polished metal. These were in existence at least four hundred years before the birth of Christ. The Egyptians, Greeks, and other early peoples used them, making them of brass and bronze, and often engraving and decorating them very artistically. The Greek sculptor, Praxiteles, first made mirrors of polished silver. These were so much better than the older ones, made of darker metals, that they became very popular and

later they formed an important article of manufacture in Rome.

During the early part of the Middle Ages mirrors were oftenest small circular discs of polished steel or other metal, and were usually carried at the girdle in beautifully carved boxes of wood or ivory. In the thirteenth century the Venetians discovered the art of making mirrors of glass, and gradually wall mirrors came into use also. The earliest glass mirrors were quite crude. The glass was coated on the back with lead or tin, and the reflections were not distinct or clear.

During the seventeenth century the Venetians began to mix mercury with tin for the back-coating and this proved to be much better. For a long time Venice supplied all Europe with mirrors, as local methods of manufacture were kept secret and other countries were slow in learning the process. Even in Queen Elizabeth's time England imported its best mirrors from Venice. It is said that the queen would use only such mirrors as made her look young and beautiful. A special kind was made particularly for her. What a pity that the method was kept secret and has been lost! How we should like mirrors to-day which would always make us look beautiful!

It was not until the middle of the nineteenth century that the modern method of making mirrors was invented. By this process silver nitrate is used instead of mercury, as this has been found to produce a better reflecting surface. For the best mirrors very fine plate-glass about one fourth of an inch thick is used. The glass is received at the factory in large sheets,

packed in enormous cases. The sheets are first cut into the proper sizes by means of diamond-pointed tools. They are then passed through several processes of polishing with emery wheels, fine sandstone, and various powders. They must be carefully cleaned with the purest water before they are ready for the silvering. For this process they are placed on heated tables and the backs are covered with a solution of silver nitrate, ammonia, and tartaric acid. The heat from the table helps the solution to stick to the glass. When the backs are dried, a coat of shellac or paint is added to protect the surface from scratches. The mirror is then ready for its frame, whether it be intended for hanging on a wall or for milady's vanity box.

If all the mirrors in all the museums in the world could give back the images which they have so proudly reflected in past ages, what an interesting story they could tell! We might gaze upon the features of Egypt's enchanting queen, Cleopatra, and on the beauty of vain Queen Bess. Secret chapters of history would be revealed to us. We should see again unrecorded scenes upon which the mirrors of old castles and palaces have looked down. Beautiful ladies, noble knights, crafty statesmen, and proud kings of olden times would gaze back at us. For the mirror is the intimate companion of the human race. One and all, we satisfy there our vanity, by seeking to see ourselves as others see us.

THE LITTLE WHEELS THAT MEASURE THE HOURS

THE date when man commenced to measure time and thus to regulate his work and activities is buried so far back in the history of the human race that we cannot be certain about it. He no doubt discovered very early, by observing the shadows cast by trees and rocks at different periods of the day, that the changing direction of such shadows was helpful to him in marking the passage of time.

Sundials were, it is believed, the first kind of timekeepers made by man. These were probably invented in Babylonia, in imitation of the trees or rocks which had served as shadow-pointers. You have perhaps seen simple sundials such as are often found in gardens to-day. A straight rod or other piece of metal is attached at an angle to a flat metal surface on which the hours are marked in a fashion somewhat resembling the face of a clock. This simple device is so placed that the moving shadow of the metal rod, as cast by the sun during the day, will mark the progress of the hours.

Many crude devices were used for measuring time before clocks were invented. A heavy rope tied in knots at regular intervals and set on fire would mark the time, as the spaces between knots would require about equal lengths of time for burning. Hourglasses were also early timekeepers. These were made of two glass bulbs joined by a very narrow opening, one of which was filled with exactly the amount of sand required to trickle through the opening in an hour's time.

Water clocks were invented in Egypt and were used for many centuries. These were made in various ways, but were usually so arranged that water slowly dripped from a vessel marked with lines for the hours. Sometimes they were made so that the weight of the water would move a hand or pointer on a simple kind of dial or face. Candles made with rings of different colors, requiring a definite length of time for burning, were later used.

Clocks were not invented until sometime during the twelfth century. The earliest were simple affairs which we should consider very poor timekeepers. They consisted of a weight attached to a cord or chain, which was wound about a revolving barrel or wheel. This barrel was in turn attached to a set of wheels which controlled a hand for marking off the hours on a dial. Often the clocks had no dials at all and the hours were indicated only by the ringing of a bell. No successful method of controlling the speed with which the weight unwound was invented for a long time. The story is told that Galileo, a great Italian scientist, first discovered the value of the pendulum by watching a lamp on a long chain, as it swung to and fro in a cathedral. He observed that the lamp swung regularly, and that the length of time required for each swing or vibration was always the same. Pendulums were not used for regulating timepieces for many years after this, but it is said that the idea of applying the pendulum to the clock occurred first to Galileo.

But the pendulum alone was not sufficient to control the weights of the clock. Some means had to be devised to keep the pendulum itself constantly swing-

ing, as otherwise it would gradually come to a standstill. At the upper end of the pendulum a little anchor-shaped piece was so arranged that one side would catch in the cog of a wheel as the pendulum swung in one direction. This would give it a little shove and start it in the opposite direction, where it would again receive a slight push when the other side of the anchor caught in a cog of the wheel. This arrangement kept the pendulum swinging until the weights had run down the full length of their cords. The clock-weights had then to be wound up again, so that the weights might start on a new journey down the cords. Large clocks to-day are made on much the same principle, but they have been constantly improved and now keep accurate time if properly adjusted.

Many curious clocks have been made during the history of clock-making. In the old cities of Europe some clocks were provided with many quaint devices for striking the hours. In Venice an old clock on a public square has a huge bell which is struck by big bronze giants. In Prague a beautiful old clock sends out every hour a whole procession of life-sized figures representing the twelve Apostles. Many towers and belfries contain large clocks which are operated by heavy machinery. The largest clock in the United States is in Jersey City. Its dial is so huge that it can be seen three miles away. Its two hands weigh more than half a ton and its pendulum weighs four hundred pounds.

Of course a timepiece with pendulum and weights attached could never be carried in one's pocket. But

as soon as people were accustomed to clocks and had begun to regulate daily work by them, they wanted smaller clocks which they could carry about. Some device had to be invented to take the place of the pendulum, and the "balance" was the result. This was a little wheel poised on a pivot, which by means of a clever mechanism was made to swing rapidly back and forth. The first watches were made toward the end of the fifteenth century. They were used by watchmen or guards who made their rounds crying the hours all through the night in mediæval towns. Thus the little clocks came to be called watches.

The modern watch is a marvelous machine. Perhaps no other piece of mechanism can equal it for delicacy, perfect adjustment, and the skill required in the making. A watch no larger than a quarter of a dollar may contain as many as eight hundred parts. This seems impossible; but if we could see all the little screws, some of them almost microscopic in size, the delicate springs, and the tiny jewels which go into the watch, we should think it more unbelievable than ever that human hands could put together so wonderful a mechanism.

The power which makes the watch run comes from the mainspring. This spring is coiled and lies inside the brass case which you see occupying about one-half of the space in the works of the watch. This spring measures one to two feet in length when straight. This is the part which we coil up when we wind our watch each day; its gradual uncoiling gives the power that moves the machinery.

Besides the mainspring there are the balance wheel

and the "train," which consists of four other wheels of different sizes, and which is controlled by the balance wheel. One of these wheels rotates once each minute and controls the second hand; another goes round once an hour and controls the minute hand; a third, which controls the hour hand, rotates once every twelve hours.

The balance wheel is a wonderful invention. Inside it is the hairspring, which is literally no thicker than a hair. It is made of steel which has been drawn finer and finer until at last it is drawn through a tiny hole in a diamond. One pound of steel will make eight miles of this wire. The balance wheel is so carefully constructed that the watch can adjust itself to any kind of climate.

Besides these parts of the balance wheel there are twenty-six tiny gold screws. These are so small that twenty thousand of them could be held in your mother's thimble. These screws are placed in pairs in the rim of the wheel, and their position and weight control or regulate the speed of the watch. The weight, therefore, is extremely important and the screws must be weighed on scales which are so delicate that they can record the weight of a pencil mark on a piece of tissue paper. To regulate the watch the screws often need to be moved many times from one place to another in the balance wheel.

Another little wheel, called the escapement, takes the place of the anchor arrangement on the pendulum, and is so constructed that it catches the balance wheel and lets it go, giving it a slight push in the opposite direction and so keeping it moving constantly back and

forth. This catching and letting go makes the ticking noise in the watch.

All these little wheels are of course set on pivots and the points of the pivots must rest on some material which will not wear away with the constant turning. Some jewels are much harder than any metal, and for this reason tiny bits of rubies, garnets, sapphires, and even diamonds are cut and then drilled to hold the points of the pivots. A full-jeweled watch contains twenty-three of these jewels, though only seven are absolutely necessary in a low-priced watch.

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SMALL SCREW WORK IN A WATCH FACTORY

You may well wonder how all these delicate parts are made. In Switzerland, which formerly led the world in watchmaking, watches were until recent years made entirely by hand. But in the United States marvelous machines have been invented which will

saw the teeth on the smallest wheels with all the necessary accuracy, turn and cut screws which are scarcely larger than a grain of sand, and draw the delicate wire for the springs. These machines seem almost as miraculous as the watch itself.

But the most marvelous work of all is the assembling or putting together of all these parts, for this must be done by hand. The watchmakers work with magnifying glasses and handle many of the little pieces with tweezers and magnets. They must be extremely skillful also in order to regulate the watch after it is put together and to know how to change the screws in order to produce the right effect. All watches before leaving the factory are carefully tested in many positions and in extremes of temperature, to make sure that they will not gain or lose time when they go into the hands of their future owners.

THE WOODEN BOX THAT SINGS

THE real name of the piano is "pianoforte," a name given it by its inventor over two hundred years ago. This inventor lived in Florence, Italy, and spoke Italian. The Italian word *piano* means soft and *forte* means loud. Many of the early ancestors of the piano — the harpsichord, the clavichord, and the spinet, for instance — made beautiful sounds and looked a good deal like our modern square or grand pianos, but their tones were much alike in strength. This Italian, named Cristofori, made the first "soft-loud" instrument of its kind.

Have you ever looked inside a piano to see what makes such beautiful sounds come from a wooden

box? You saw there many shining steel strings tightly stretched from one side of the box or case to the other. From these strings the music comes. Many other musical instruments are made by tightly stretching strings of some sort over a strip of wood or metal, so that they will quiver or vibrate when touched and produce a beautiful singing sound. The piano is so made that, when its keys are struck, little hammers hit these steel strings and make them vibrate.

If you noticed the strings closely you discovered that those which make the high treble sounds are very fine and delicate, while the bass strings are quite coarse and are made even heavier by being wrapped closely with fine copper or brass wire. The coarse strings do not vibrate as rapidly as the fine ones and therefore they give a much lower note. The number of vibrations which a string makes in a second determines its high or low pitch.

A great deal of care must go into the making of a piano, as every part must be perfect in order to help make the beautiful rich tones which we love. Even the selection of wood for the case is a very important matter and only an expert can tell whether it will be suitable or not. The wood which is used is often dried or seasoned in the open air for eight or ten years, and is then carefully cured for weeks in artificial heat. The case must be very strong in order to hold the heavy iron frame on which the strings are strung. It is made by cutting the wood into thin strips which are glued together until a sufficient thickness is obtained and then held tightly in a press until dry.

The strings are made of the best steel wire and are stretched from a heavy iron string-plate on the back side to the tuning pins in the "wrest-plank" on the front side of the frame. The tuning pins are set so that they can be turned to tighten or loosen the strings

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TUNING PLAYER PIANOS AT THE FACTORY

in order to give each note the precisely correct pitch. Beneath the strings is the sounding board, which is made of thin strips of wood very carefully glued together and is for the purpose of increasing the sound and throwing it out into the room. The hammers, which are attached to the keys for the purpose of striking the strings, are covered with a fine grade of felt made from the wool of merino sheep.

Materials from many countries go into the making

of our modern pianos. The ivory and ebony used for the keys come from far-away Asia and Africa. Some of the woods used in the case come from South America, the Philippines, and the West Indies. The iron ore, which is used for making the plates and tuning pins, and the steel for the strings may come from the United States, England, or Sweden. The wool used for the hammer felts often comes from Australia, South America, or Africa.

Many countries have helped in the development of the piano. Vienna, a beautiful city in far-off Austria, has given some of the most important improvements to the grand piano, while other helpful ideas have come from Italy, Germany, France, England, and the United States. The piano is truly a gift from many lands. On it musicians from all countries can speak to us even though they cannot use our words in conversation. Music is a language which people from all parts of the world can understand.

THE MECHANICAL EYE THAT EXCELS OUR OWN

Until modern photography was developed with its undreamed-of possibilities, the human eye seemed astonishing in its ability to reproduce for our instruction and delight the world of nature about us. We believed that every image which presented itself was at once reflected or pictured on the retina or sensitive plate of the eye. We little dreamed how many things were going on in the world which we were unable to see.

But the modern camera has so excelled the human eye that it has opened up for us a whole new world. With the speed of a flash of lightning it can record all the details of a large and complicated scene, such as the eye could discover only after close and prolonged examination. With its remarkable speed and accuracy the camera can record motions which are much too swift for the eye to observe at all. With an exposure lasting only 1/3000 of a second, photographs have even been made showing the different steps in the bursting of a soap bubble, as it was shattered by a bullet. By means of powerful lenses, which are indeed superhuman, photographs of the heavens have been made, showing stars that are invisible to the human eye even when aided by the largest telescope. Cameras with a microscope attachment can produce for us in permanent form exact pictures of little plants and animals that live in the air and the water and are far too minute to be seen by the eye. In the invention of photography and in its modern developments man has indeed surpassed Nature's own handiwork.

Modern photography and its wonders are the result of centuries of baffled hope and persistent experiment on the part of scientists. As early as the sixteenth century it was discovered that a tiny hole in a dark box, or "camera obscura," would admit rays of light from any object in front of the hole and form an inverted image of the object on the opposite side of the box. This discovery was the first step toward photography and for nearly three hundred years it presented a tantalizing problem. How could this image, formed by the

sunlight, be made permanent or lasting? The power of the sun's rays to change colors by means of chemical action finally gave the key to the secret.

You have noticed that the sun can tan your skin, fade the colors in your clothing, and even bleach some cloth until it is perfectly white. By accident it was discovered that some chemicals are so sensitive to sunlight that they change color instantly. Most salts of silver have this characteristic. One of these salts, like silver bromide, when dissolved in some substance such as gelatin and spread on a plate of glass or metal, would therefore form one of the essentials in photography, consisting of a sensitive plate for catching the image in the dark box. Wherever the light reflected from an object entered the camera and fell upon this plate, the salt would change color and reproduce an image of the object.

Another important discovery was that rays of light in passing through a glass lens become much stronger. How many of you have lighted fires by intensifying the sun's heat through a convex glass lens? It was found that by using such a lens instead of a hole in the dark box, a much clearer image could be obtained.

But the problem now was to "fix" the image in the silver salt, for of course the entire plate would change color as soon as it was removed from the camera and exposed to light, and the picture would be blotted out. This led, after long and patient experimenting, to the discovery of chemicals which would develop and fix the silver in the image and dissolve the unchanged salt from the plate.

But this "fixed" plate, or negative as it is called, is still far from being a photograph. The negative shows everything backward. Black is where white should be. Your face and hands are black and your coat is white. The printing of the picture from this negative is the final step in the production of the photograph and very cleverly turns the black spots white and the white ones black. Between the negative and a bright light is placed a piece of specially prepared paper. This paper is also coated with a silver salt which is sensitive to light. The light passes readily through the light spots in the negative but less easily through the dark spots. Thus the paper receives a dark spot corresponding to every light spot in the negative and your face and hands come out looking as they should. The paper, after this exposure to the light, must also go through chemical developing and fixing solutions. It is then washed and dried, and behold! the miracle is completed.

Many names are connected with the history of photography, but those of two Frenchmen, Niepce and Daguerre, stand at the head of the list. Niepce labored almost unceasingly for twenty years and spent his entire fortune to learn the secret which he was sure existed. Finally, about 1827, he produced the first fixed or permanent photograph. Daguerre, his fellow worker, discovered still better developing chemicals, and his name is immortalized in the old "daguerreotypes," the metal photographs in which the faces of our great-grandparents have come down to us.

Those early photographs were far from perfect and the time of needed exposure was inconveniently long.

To have a daguerreotype made, your great-grandmother had to pose twenty minutes! Many improvements have been made since the time of the pioneer photographers, but to an American belongs the credit for one of the most important. The camera with it gelatin-covered glass plates is heavy and cumbersome to carry about. George Eastman of Rochester, New York, perfected the modern kodak with films in place of glass plates. These films are made of celluloid coated with the necessary silver salt. They are easy to carry in their neat rolls and have converted the camera into a fascinating toy within the reach of every amateur who realizes the fun of picture-making.

The possibilities of this mechanical eye, the camera, are not yet fully developed or realized. Photography adds more to the interest of our daily life than we recognize. Think how much more the pictures in your schoolbooks tell you than the printed words are able to do. Can you even begin to estimate the interesting things you have learned about the world and its wonders from the moving-picture films, those animated new brothers of the kodak?

Photography is now one of the principal recorders of history. How much more we should know of ancient times if the inquisitive camera had only been there to see for us! We should have faithful likenesses of beautiful Helen, of wicked Nero, and of good Saint Francis. The history which we are making to-day will live for our descendants with great vividness because of this truth-telling eye which man has invented.

MAKING SOUND IMMORTAL

THROUGHOUT the early ages many tribes of mankind believed that certain stone and wooden objects without life had the power of speech, and these they held in great reverence. In some savage tribes to-day the same belief still exists. The old sibyls and soothsayers, medicine-men and witch doctors, did a thriving business in frightening their tribesmen with tales of the voices of gods or of powerful spirits, heard among the rocks, waterfalls, and caverns. In history there are interesting stories of great statues that were believed to sing at dawn; Sphinx-like figures that answered questions; singing and speaking boxes of Chinese princes; the three-word box of Roger Bacon; the "brazen head that spoke," made by Magnus and destroyed in anger by his pupil after forty years of work.

All these and many other stories show us how anxious people were to imitate human speech by some mechanical device. Most of the early experimenters tried to copy in wood or metal the shape of a man's head and throat. Perhaps people never thought about keeping or preserving sound already made — or using the idea of the echo in making a talking machine, or catching the waves of sound and holding them for resounding in the future.

We are told that there can be no sound without motion. No sound can be heard without air, water, stone, earth, or some other body about it to carry the sound set in motion. If you strike a glass lightly with a knife and touch your finger to its edge you can feel

the vibration or trembling of the glass. Press down on the glass and the sound will cease. Toss a stone into a pond and watch the ripples spread in all directions. Sound is carried in the same way by waves in the air or in some other medium. Someone speaks and from his lips come puffs of air. The waves of air caused by this disturbance reach our eardrums, whose immediate vibrations translate to us the meaning of the speaker. We hear the sounds which he made.

It was Thomas A. Edison who made in 1877 the first successful machine to record or catch the waves of sound and reproduce or re-sound them for us. His invention preserves speech, while the camera preserves light. The idea occurred to him while working on a new invention for the improvement of the telegraph. Its principle was similar to that of the receiver and transmitter of the telephone. He used a thin flexible disk or plate which easily vibrated to sound waves, and by means of an attached cutting needle he transmitted these waves in faint lines to a revolving wax cylinder or tube. The vibrating needle left little bumps and hollows in making the line in the wax. When the cylinder was turned back for the needle to follow the line already made, the disk received again the same vibrations and sent out on the air the same sound waves as before. The first message received and sent by this mechanical ear and voice was a verse of "Mary had a little lamb."

Following that great day many marvelous improvements have been made, and millions of perfected phonographs are in use throughout the world. Perhaps the most important improvement was the flat-disk style

of record; durable, easy to preserve, simple to operate, and easy to reproduce in great quantities. Of course only one record, the original or "master" record, is made directly from the voice of the performer. All the rest are made from the master record by improved methods of electrotyping. The disks are usually made of coal-tar products, by secret processes carefully guarded by the manufacturers.

Many improvements have also been made in the various kinds of needles now in use, some of which are tipped with tungsten, glass, sapphire, and even diamond points. The driving power of most machines is a clockwork mechanism operated by a spring, which revolves the record on the turntable with the necessary regular speed. Note the care which has been given to the perfections of the horns and cabinets, to increase and to soften the sound.

Sound is a fleet messenger and is soon gone, if not captured and held for future service by the phonograph. The limits of its possibilities for entertainment and instruction have not yet been reached. The preservation of music, speech, language, and folklore, and the advance of popular education are chief among the benefits given to the world by Edison's talking machine.

RADIO AND ITS WORLD NEIGHBORHOOD

Forty years ago the telephone, with its marvelous network of wires, enabling people to talk with friends in far-distant places, was still looked upon as magic to be understood only by electrical wizards. About that time Marconi, an Italian by birth, was experi-

menting with even greater marvels. He was working out successfully an unbelievable method of transforming sound so that it could be sent through miles of space without wires. To-day, only a little more than a quarter of a century since Marconi first proved his ability to telegraph by "wireless," the world is accepting almost as an everyday fact the still greater magic of sending the human voice thousands of miles through space by means of the radio or wireless telephone.

Long before young Marconi began his experiments, scientists had proved that sound produces ripples or waves in the ether, much like waves in water. Each sound has its own kind of waves. Deep sounds make larger waves, which are fewer and farther apart than those made by high, shrill sounds.

But sound, we know, cannot travel far enough to reach the human ear at a great distance. Painstaking experiments finally proved that electric waves which will carry sound can be sent through the ether at the tremendous speed at which light travels. Ordinary sound-waves travel at the rate of one thousand and one hundred feet a second. That seems fast enough for most purposes; but if it were possible to send one's voice by sound waves from New York City to Chicago it would take a whole hour for the words to travel the distance. Light travels at the terrific rate of one thousand million feet a second. That is so fast we can scarcely comprehend it.

Marconi discovered that by means of an electrical machine called a "transmitter" or "generator" sound waves could be changed into electric waves that would

travel at this great light-speed. He experimented only with the wireless telegraph and transmitted sounds by means of a Morse telegraph key, which delivered its message by means of dots and dashes, — short and long taps, — certain groups of which stood for the letters of the alphabet. The messages could be heard at any receiving station that was properly equipped with an electrical machine to change the electric waves back again into sound waves. Marconi's instrument was satisfactory for sending out these telegraphic messages, but it was far too imperfect to transmit the human voice, with all its range and many changes in pitch. For instance, the electric waves created by the Marconi apparatus had a tendency to die down and were therefore unsuited for carrying voice-sounds.

Many improvements have been made since Marconi invented his first transmitter, the most important being the vacuum tube. This looks somewhat like a long electric-light bulb, but is a much more delicate instrument. It can be used for sending out continuous electric waves, that is, waves which do not die away, but which persist or continue and carry the human voice successfully. It can also be used in the receiving stations for increasing or amplifying sounds when they arrive from such a far-away station that they can scarcely be heard. This little instrument has revolutionized the wireless telephone and telegraph.

Many other improvements have been made in the detectors or receiving instruments, so that each year it is possible to hear radio messages with greater clearness and accuracy. Wireless transmitting or broad-

casting stations are so constructed that they send out sounds of a single wave-length. Receiving apparatus is now so made that it can "tune in" — or be adjusted — to receive sounds from any broadcasting station desired, provided the wave-length used by the station is known.

The wireless telephone is best known to us because of the popular concerts and other programmes which are broadcast daily from hundreds of transmitting stations in the United States. In 1920 the Westinghouse Electric and Manufacturing Company conceived the idea of sending out musical concerts by means of radio. It proved to be a great success. People all over the United States, no matter how far removed from large cities with their theatres and concerts, could install their own receiving sets and listen to radio programmes from a dozen different cities each night, if they so desired. Broadcasting sets were installed in churches, lecture halls, opera houses, and theatres, and the variety of radio programmes increased enormously.

Besides this popular and entertaining side of radio there is a more serious side. By means of the wireless telephone the safety of ships at sea is greatly increased. Distress signals sent out to other ships have frequently resulted in the arrival of timely help and the saving of many lives. Weather reports are now broadcast by radio and often can be sent early enough to enable fruit and vegetable growers to protect their crops from heavy, killing frosts. With improvements in broadcasting, it is already a simple matter for messages to be sent from one continent to another, and the time is

undoubtedly not far off when a human voice can be heard around the earth.

The future possibilities of wireless are more than anyone can predict. No matter how wild a dream the radio engineer may harbor in his daring brain, it can

By courtesy of the American Telephone and Telegraph Company

RADIO ROOM ON THE UNITED STATES LINER AMERICA

be no more astonishing than the marvels which have already become facts. Experiments have been successfully carried out in which aeroplanes and ships at sea, launched without crews, have been directed and controlled by radio. Radio science will no doubt soon be perfected so that travelers may talk easily from moving trains to friends in distant cities. The time is surely

coming when pictures will be transmitted by radio, and we shall be able to see the faces of speakers who are broadcasting across a continent. Attempts have already been made to signal other planets and the time may come when we shall send messages to Mars as easily as we now broadcast a bed-time story. By means of this marvelous discovery of the powerful electric waves which can carry the human voice, we shall have next-door neighbors in Lapland, Madagascar, and Timbuktu, and shall hear the news of the day over the world's wireless back-yard fence.

THE INVENTION OF POSTAGE STAMPS

SUPPOSE our letters always came to us with postage due. Can you imagine how inconvenient this would be? If no one happened to be at home when the postman came, your letter would be delayed until such time as he could find you there. In the days before postage stamps were invented this is what happened. The receiver always paid in money the charge due for carrying the letter. Also, in the old days, he had to pay much more than now; for charges, even in a single country, were based on the distance the letter had to travel. In so small a country as England one often paid as much as twenty-five cents (a shilling) for a letter.

Postage stamps, as we know them to-day, were invented by a Scotchman in 1834, but they did not come into general use until a law made by the British Parliament in 1840 required it all over the country.

In the United States our stamps are made by the Government Bureau of Engraving and Printing in

Washington. This establishment makes several millions of stamps in a day, so you know that the stamp-printing machines must work rapidly.

Before stamps can be printed a die must be prepared. This is a small steel block with the design engraved on it. The design must be authorized or made legal by the United States Government before stamps can be made from it. When the die is finished it is impressed many times on a steel plate, so that two or three hundred stamps can be printed side by side at a time. Three such plates are fastened into a press, and are then ready for inking and printing.

The stamps are printed on huge sheets of paper and are then dried and sent to a gumming machine, where they receive a coat of mucilage on the back. The sheets are passed between two rollers, one of which is dry and the other moistened with mucilage.

After being dried in a steam-heated box they are sent to a perforating machine, where they receive the rows of little holes which you always see between stamps. In this machine the stamps are passed between two rollers, one of which bristles with steel pins while the other has holes which exactly fit the pins. This arrangement perforates the sheets with rows of holes in just the right places.

To prevent curling up because of the mucilage, the sheets are finally squeezed in a powerful press until they lie quite flat. They are then ready to send out to post offices all over the country.

A new machine, which has been in limited use only a few years, greatly simplifies the process of stamp-

making. It prints, gums, and perforates the stamps and finally puts them up in rolls for stamp-selling machines such as you see in drug stores. This machine can print four million stamps in a single day.

The last yearly report of the Bureau of Engraving and Printing says that in the year 1922 alone there were over fourteen billion stamps printed. If all these stamps were laid end to end, they would reach all the way across the United States more than twenty times, or around the earth over nine times!

PART VIII

IN MOTHER'S SEWING-ROOM

SEVENTY-FIVE YEARS OF THE SEWING MACHINE

SEWING machines have been in general use only about seventy-five years. Before their invention all clothing had to be made by hand. Leather articles, such as gloves and shoes, were stitched by hand with great difficulty. It is not surprising, therefore, that one of the first sewing machines invented was for stitching leather. This was the device of an Englishman. But the machine never came into general use; probably it was too crude to be successful.

About 1838 a French tailor invented a sewing machine which was successful for a time. It was made almost entirely of wood and was very clumsy, but a few more like it were made and used in a factory for manufacturing soldiers' uniforms. This made the tailors angry, as they feared their business of making men's clothing by hand would be quite ruined if machines came into use. A mob of workmen attacked the factory, destroyed all the machines, and almost killed the poor French inventor.

By this time many people were considering the possibility of sewing by means of machinery, and several men invented various kinds of apparatus within the

next fifteen or twenty years. As the United States now leads the world in the manufacture of sewing machines it is fitting that the credit for inventing the first successful one is given to an American, Elias Howe, who secured a patent for his machine in 1846. This machine was the first which used two threads in making the stitch — one passing through the needle and the other coming from a shuttle or bobbin.

Elias Howe had a hard time convincing people that his machine would stitch better and more rapidly than they could sew by hand. Many people laughed at him. Finally he made a wager that his machine could sew five times faster than anyone could sew by hand. He invited five excellent seamstresses to run the race with him. He himself took five garments to be made and each of them took one. They all sewed as fast as they could, but Elias Howe had finished all five of his garments long before the others. Even this did not perfectly convince people, and he met a great deal of opposition from tailors just as the Frenchman had done a few years earlier. He did finally become a very rich man from his invention, and he lived to see the time when sewing machines were in general use.

Many parts go into the making of a sewing machine. Most of these are made in the same factory and all are now made by machinery. Wood, cast iron, and steel are used. The heavy parts, including the arm, or upper part, and the treadle, are made of iron. The finer, more delicate parts are of steel. The table is of wood and the upper wheel is usually of iron with a coat of nickel.

The cast-iron parts are made by moulding. Each

part requires a separate mould made of sand, with the inside just the size and shape of the part to be made. Hot liquid iron is poured into these moulds and allowed to cool, coming out quite rough and unfinished, but of the desired shape. The parts are then finished smooth, cleaned with acid, and given their coat of black varnish.

All the parts finally meet in the "assembling room," and are there put together by hand. Before the machines are called complete they are tested, to make sure that all the parts are perfect and that they fit each other exactly, so that the machine will run smoothly and make a perfect stitch.

Sewing machines are divided into two large groups, according to the kind of stitch made. The lock stitch uses two threads, as did the early invention of Elias Howe. The thread in the needle forms a loop below the cloth and the other thread is carried through the loop on a shuttle, thus "locking" the stitch. The chain stitch is made with one thread and resembles the chain stitch used in crocheting. For this stitch the thread passes through the cloth and by means of a hook is caught through the loop of the previous stitch.

Many kinds of sewing machines have been invented since 1846. They are used for making shoes, gloves, harness, and clothing, and for stitching all kinds of materials, including heavy canvas, leather, and the finest silks and laces. Many different attachments have also been invented, so that by fastening a special part to the machine various kinds of fancy sewing can be done. It is now possible to hemstitch, ruffle, hem, tuck, embroider, and make buttonholes on the machine.

Most of the machines which are for use in clothing factories are now run by electricity. These are marvelous machines, some of them making as many as four thousand stitches a minute.

MAKING OUR CHEAPEST CLOTH

It is surprising to observe the clothes people wear and to count the many kinds of material used to make them. Among these, textiles or woven cloths are the most important. Cloth may be made of many things, but always the fibres, threads, or hairs of some plant or animal are used. The four most common kinds of cloth are cotton, linen, silk, and wool. Cotton and linen come from the fibres of plants, silk from the delicate little filaments which the silkworm spins, and wool from the hair of animals.

Cotton is the cheapest of all textile materials and is probably used in more ways than any other. It comes from the seed pods of the cotton plant, which grows in warm countries. More cotton is raised in the southern United States than in any other part of the world.

Have you ever seen fleecy, white bolls or pods of cotton? The plants fill large fields and are usually not more than two or three feet tall. The flowers look much like hollyhocks. A whole field full of blooming cotton is a beautiful sight. These blossoms last only a single day, but their life is not monotonous. In the early morning they are a creamy white; as the day advances they gradually change their color to a soft rose and then to red; and in the evening the petals drop from the plant. In dropping off they make way for the

seed pods, which grow and swell until they are nearly as large as eggs. When they are ripe they pop open and the snowy balls or "bolls" of cotton burst into view. The seeds are embedded in these soft white cushions. A field full of white cotton bolls is one of the loveliest things to be seen anywhere. The cotton when quite ripe is ready to be picked. The picking-season lasts from July to Thanksgiving time, as neither all the blooms nor all the bolls appear at any one time.

By courtesy of the First National Bank of Boston

FLEECY WHITE COTTON BOLLS

If you have ever squeezed in your hand the cotton from one of these bolls you have discovered that it is filled with little hard lumps. These are the seeds; they are tightly wrapped in the long cotton fibres and are hard to pick out. For a long, long time these seeds were taken out by hand, but the work was so difficult that one person could not prepare more than one pound of cotton in a day. In 1794 Eli Whitney invented the cotton gin, which was a machine for combing or scraping out the seeds. This was a very important invention, as it was then possible to prepare cotton for the market much more rapidly than before. Cotton became much cheaper, and cloth was manufactured in larger quantities, so that more people could use it.

When the cotton has been passed through the gin it is pressed into huge bundles or bales weighing four or five hundred pounds, which are wrapped with heavy burlap cloth, bound with strips of iron, and sent to the

mills of cloth manufacturers. Many thousands of bales are shipped away from the United States every year, as we supply manufacturers in all parts of the world with this raw cotton.

Cotton fibres are quite short, the longest, which come from "sea-island" cotton, not measuring more than two inches. Many processes must therefore take place before these short, delicate fibres can be changed into threads long and strong enough for weaving into cloth.

By courtesy of the First National Bank of Boston

BALE OF COTTON SENT TO THE MILL

When the bales are opened the cotton appears dirty, being filled with dust, twigs, and bits of leaves. The bales are unwrapped and thrown into a bale-breaker, where the cotton is thoroughly beaten and shaken, a current of air constantly blowing through the machine to drive out dirt and dust. During this process the cotton becomes so light and fluffy that a baleful would fill almost a whole room if allowed to scatter. It comes from the machine in a fluffy white sheet, but the fibres are tangled and lying in every direction. Before they can be twisted into thread they must be straightened and laid parallel. This is done in a carding machine, which combs the fibres by means of thousands of fine

steel teeth. The filmy sheet which comes from the carding machine is then rounded into a soft, white rope about the size of a man's finger. This long rope is passed through one machine after another, being twisted, stretched, and twisted again, growing slenderer but stronger, until it at last resembles the thread you will see if you ravel a piece of cotton cloth. This process is called spinning.

The cotton yarn — as it is usually called to distinguish it from sewing thread — is now ready for weaving into cloth. The weaving takes place on a loom, which is a wonderful and complicated machine, so made that it can weave lengthwise and crosswise threads together. On the loom thousands of threads are stretched lengthwise. These are called the warp threads. The crosswise threads, which are called the woof or filling threads, are wound on shuttles or spools with pointed ends. The loom is so made that the warp threads can be lifted alternately: that is, the first, third, fifth, and other odd threads are lifted at one time and the shuttle darts through, between the odd and the even, carrying the woof. Before the next trip of the shuttle the odd threads are lowered, and the even ones, the second, fourth, sixth, and so on, are lifted. When cloth is so fine that one hundred or more warp threads are used to the inch, you can imagine how marvelous this loom must be. The loom works so perfectly that usually one man alone can care for sixteen to twenty-four machines. If a single thread breaks in the weaving the loom stops at once, and the workman can soon locate the trouble.

Weaving has been done for thousands of years.

Primitive women in nearly all countries know how to do some form of hand-weaving. They use any materials which they can find, whether grasses, reeds, hair, or plant fibres. We have learned that the first form of weaving was probably used by savage women in making baskets. No doubt the making of baskets first taught people how to make cloth.

When cloth has been woven it is ready for the finishing processes. If it is to be white, it must be bleached, as the fabric made from the natural cotton fibre is grayish or yellowish. The bleaching, or whitening, is done by means of a chemical, usually chloride of lime. This is so strong that it will take out all color.

The dyeing of cloth is done in many ways. Sometimes the yarn is dyed before the cloth is woven. For such materials as checked ginghams, threads of the various colors are used on the loom and are woven together into a pattern. Other cloth may be dyed all one color, or a pattern may be printed on it. Cloth is printed much like newspapers. The pattern or design is engraved on a roller, below which the dye is placed in a trough. The cloth is then run over the roller and the colored design is stamped on it. If several colors are to be used, there is a roller for each color in the pattern, and the cloth is passed over each roller in turn. Sometimes cloth is dyed a solid color and the pattern is stamped on by a "discharge" process. The design on the roller, instead of being covered with a dye, comes in contact with a bleaching chemical which takes out the color, leaving a white pattern. Polka dots are often printed on cloth in this way.

No one knows when cotton was first woven into cloth. As the fibres are so short, it is not surprising that man did not learn how to use it as soon as wool, silk, and linen. Yet beautiful cotton cloth was made in India hundreds of years ago. The Indians of South America knew how to make cloth of cotton, and ancient mummies wrapped in this cloth have been found in Peru, the home of the old Inca civilization. When Columbus discovered the West Indies he found the natives of those islands using a cotton cloth which they knew how to weave and dye beautifully.

THE SILKWORM AND THE PRINCESS

THE art of making cloth from the delicate filament which the silkworm spins was devised by the Chinese thousands of years ago. An old Chinese legend tells that it was a princess who first learned the secret of how to do it. She tended the silkworms herself and with her own hands spun and wove their threads into soft, lustrous cloth. Whether the story is true or not, the Chinese still celebrate her memory with a festival each April and they call her the Goddess of the Silkworms.

For many hundreds of years the people of China guarded their secret, making it a crime which might be punished by death to carry silkworm eggs away from their country. Fortunately for the rest of the world, however, the secret did leak out, and India and Persia began to raise silkworms and make silk. There is a story of another Chinese princess who married an Indian prince. When she went to live in her new home she

carried some silkworm eggs sewed up in her headdress, and with the worms hatched from those eggs the silk industry in India was started. Tradition tells us that the Emperor Justinian, who reigned long ago in Constantinople, persuaded two monks to go to China and bring back silkworm eggs. The monks would have been killed if their purpose had been discovered in China, but they hid the eggs in hollow canes and succeeded in bringing them all the way back. Thus, so the stories say, silkworms were introduced into Europe.

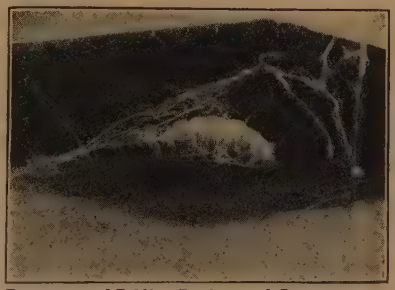
By courtesy of Belding Brothers and Company

FULL–GROWN WORM EATING LEAVES

The silkworm belongs to the moth family, so it really is a caterpillar instead of a worm. Many kinds of caterpillars spin threads just as the silkworm does, but few of these threads are fit for spinning and cloth-making. When the caterpillar first hatches from the egg it is very tiny, being not more than one-eighth of an inch long, and is covered with short black hairs. Its chief characteristic is an enormous appetite, and it at once begins to eat. Its favorite food is the leaf of the mulberry tree, so the worms are raised most successfully in climates where the mulberry grows well. Each day of their lives the little worms eat as much food as they themselves weigh. This makes them grow very

rapidly. A large number of worms, such as are usually raised together, will consume an enormous amount of mulberry leaves in a very short time.

The worms grow so rapidly that they soon split their skins. Then they hide for a day or two until the skins have been shed. They come back hungrier than ever and must be fed more than before. A roomful of worms all eating leaves at the same time makes a noise like falling raindrops.

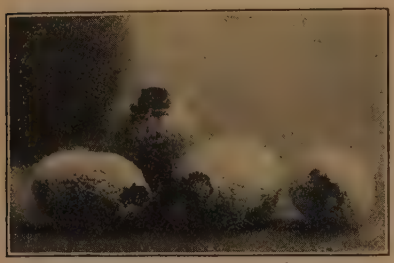


By courtesy of Belding Brothers and Company

SILKWORM STARTING ITS COCOON

When the creatures are about a month old they have grown until they are two inches or more in length and as large around as a lead pencil. About this time they lose their appetites and become restless. They are hunting for a twig or some comfortable place to rest, for they feel that the time has come to begin to spin. Inside each worm are two little bags extending down its sides and filled with a sticky, jelly-like substance. When the creature has attached itself to a twig it begins to spin about its own body a little sack or cocoon made of this substance. It comes from a tiny opening in the lower lip, and as soon as it reaches the air it hardens into a fine thread, much like that in a spider's web. The worm spins the outside of the cocoon first, moving its head back and forth in the form of a figure eight. It

shuts itself in, and still keeps on spinning until it has wrapped itself in a cocoon about the size of a pigeon's egg and its two bags are quite empty. Then it goes to sleep. If left quite alone, but kept comfortably warm, something wonderful happens. It changes into an entirely different creature, and at the end of two or three weeks comes out of the cocoon in the form of a beautiful yellowish-white moth. The moth performs its duty in the world, which is to lay eggs, and then it dies. The eggs hatch, and a new family of silkworms is ready to start on a similar life-history.



By courtesy of Belding Brothers and Company

EMPTY COCOONS — MOTHS HAVE ESCAPED

When the moth breaks through the cocoon, the thread is torn in so many places that it is quite ruined for making the finest and most beautiful silks. The silkworm-grower, therefore, kills the chrysalis before it has time to break its precious wrapping. This is done by means of steam, by very hot sunshine, or by baking the cocoons in an oven.

The next process is to unwind the long filament which the worm has so carefully spun. The cocoons are placed in warm water to soak off the gummy substance which binds together the two parts of the thread, each part having come from one of the two separate little bags inside the worm. The ends of the threads from four or five cocoons are caught together, drawn through

a tiny ring, and wound on a reel or spool as a single thread. The skeins of silk which result from this winding are known as raw silk, and are sold in that form to the manufacturers. Each cocoon contains about four thousand yards of thread, but as the parts on the outside and farthest inside are not fit for winding, they are known as waste silk. Not more than twelve hundred yards of the thread are wound on the reel.

Many attempts have been made to raise silkworms in this country, but it has been found impossible to do it in large numbers. The United States, therefore, imports raw silk in enormous quantities. About half of its silk comes from Japan, one quarter from China, and a great deal from Italy. The United States now leads the world in the manufacture of silk fabrics, though France held this position until about twenty years ago.

The raw silk, after being cleaned and scoured by boiling in soapsuds, is spun and woven much like cotton yarn. The spinning of the silk thread is called "throwing." The fine threads from the skein are twisted and combined into larger threads of various sizes, more suitable for weaving. The threads may be dyed before the weaving takes place, or the dyeing may be left until the cloth is woven. Silks dye easily and may be transformed into the most beautiful and delicately colored fabrics.

The silk from the wild silkworm, found in some parts of the world, is not so beautiful as that from the cultivated worm. The cloth woven from wild silks is apt to be uneven, but it will often wear much longer. It is darker than the cultivated quality, and will not take

dyes so easily. It is used a great deal in the manufacture of so-called "pile" cloths, such as velvet, plush, and imitation sealskin, and in rough silks, such as pongee.

The waste silk which we spoke of as being unfit for reeling off the cocoon is not actually wasted. This, as well as the silk out of the cocoons from which the moths have hatched, may be used for cheaper grades of textiles. Short, broken fibres are carded and combed like cotton fibres and are then spun into long yarns suitable for weaving. Silk of this grade is used in the manufacture of knitted goods, such as hosiery and tricolette, and for making embroidery floss, braids, and crochet silks. The thrown or reeled silk, as the better kind is called, is used for making fine silk cloth, ribbons, and sewing thread.

Ribbons are woven on a loom just like the wider cloths, the only difference being that ribbons are so narrow that several strips can be woven on one loom at the same time.

Velvets are also woven on a loom, but differ from ordinary silk cloth in having a shaggy side or pile. This is formed by an extra set of warp threads which are left standing in little loops, so close together that the woven threads underneath do not show at all. When the cloth is finished the loops are cut evenly, so that the little ends stand up all over the surface. When these ends are specially long the cloth is called plush. Velveteen is woven in much the same way, but is made of cotton.

FROM FLAX TO FINE LINEN

LINEN has been used many thousands of years for making clothing. It is one of the very oldest textile materials known to man. Small pieces of linen have been found in the caves and buried towns which belonged to the men of the Stone Age, when people still made their tools and weapons of stone instead of metal. Some of the mummies found in Egypt are wrapped in long strips of fine linen which must be four or five thousand years old. In Bible times linen was in use but was apparently considered a great luxury; it was a mark of wealth and elegance to be clothed in "purple and fine linen."

Before the cotton gin and other machines for the rapid production of cotton cloth were invented, linen was more used than any other cloth. Because the raising and care of flax for linen must be done almost entirely by hand, linen has become more and more expensive in this age when so many things are made rapidly by machinery. For this reason it ranks now about fourth among the fibres which are used for cloth.

It is the strongest of the vegetable fibres, and has so many other excellent qualities that it is still greatly desired, in spite of its cost. It wears well, absorbs moisture easily, does not soil quickly, is smooth and soft, can be spun into a very fine and delicate thread, has a sheen or lustre almost as beautiful as silk, and becomes more beautiful each time it is laundered. It is used for making clothing of all kinds, fine laces, beautiful table-linens, bed-linens, towels, and handker-

chiefs. Because of its great strength, it is much in demand for the manufacture of aeroplane wings.

Linen is made from the long stem-fibres of the flax plant. Flax is cultivated in large fields where there is plenty of moisture. The flax plants are tall and slender. When in bloom their delicate blue blossoms are very lovely waving in the breeze. The linen fibre grows in a thin layer just beneath the bark of the flax stalk, is slender and straight, and may be from twelve to thirty-six inches in length.

Flax is raised for two purposes. Besides giving us the linen which can be made from its fibres, our valuable linseed oil comes from its seeds. This is almost as important as linen, for it is used in paints and varnishes and in the manufacture of linoleum, oilcloth, patent leather, and other smooth-surfaced materials.

Unfortunately, the flax raised for linen cannot also serve to produce linseed oil, because the stem fibres become too woody and tough if allowed to stand until the seeds are ripe. They can then be used only for making very coarse materials, such as crash.

For the making of good linen the flax must be gathered in July or August. The stalks are pulled up by the roots by hand, in order not to injure the fibres. After drying for a time, the process of rippling takes place. The stalks are held against revolving wheels or cylinders which beat out the seeds. In some countries the rippling is done by drawing the stalks across rakes or boards filled with spikes.

The next process is called "retting." By this process all parts of the stalk except the fibres are rotted away

so that they may be easily separated. In some countries "dew retting" is used, and the stalks are allowed to lie out in the field in the dew, rain, and sunshine until the retting is completed. In Ireland and several other countries "pool retting" is practised. The stalks are tied in bundles and lowered into quiet pools or ponds. The running-water process is best, but this has been successful only in Belgium. During the retting season the River Lys may be seen crowded for miles with flax in weighted frames. Some unknown substance in this river water makes the retting here more successful than in any other part of the world. During this process the flax must be watched carefully, as the fibre is ruined if the retting lasts too long.

Next the stalks are dried and run through a breaker which loosens all the dead matter from the fibres. In the scutching machine they are thoroughly beaten, so that the broken pulp falls away. The fibres are then hackled, or combed, in order to straighten and separate them. The short, broken fibres which result from this process are called tow, and are used in making coarse towels and other similar fabrics.

The fibres are then spun and woven. The weaving looms are similar to those used for cotton weaving, except in one way. Since linen fibres do not stretch as much as cotton, but break more easily, the machine must be more delicately made, in order to stop at once whenever a thread breaks.

After the weaving, the bleaching and dyeing take place. The best bleaching is done on grass, where the cloth is allowed to lie for six or eight weeks in the

sunshine. Most of the Irish linen is grass-bleached and it is usually very beautiful. A quicker method of bleaching is by the use of chemicals, but these often injure the fibres and the cloth does not wear so well. Linen does not dye so easily as cotton and silk, and it fades more rapidly. For this reason white or unbleached linens are more used than colored ones.

More flax is raised in Russia than in any other country. A great deal is raised in Belgium, Holland, Ireland, France, Egypt, and northern Italy. In the United States a great quantity of flax is raised, but it is used mostly for linseed oil.

WHY SHEEP NEED GOOD SHEPHERDS

Has it ever occurred to you, when you have seen a flock of sheep grazing in some pasture, that your next winter's coat might at that very minute be growing on the back of one of them? Many of our garments are made of wool which was the pretty white fleece or coat first intended to keep the sheep itself warm.

The hair of many animals is used for making cloth, but sheep's wool is the most important. Wool is generally wavy or kinky and this makes it spin easily into yarn. The fibres are covered with little scales which can be seen only with the microscope, and these scales help the fibres to cling together and so make woolen yarn strong and woolen cloth very firm and compact. Because of these scales some woolen materials, such as felt, are not even woven, but are made to hold together by means of heavy pressure.

The beauty of woolen cloth depends a great deal on

the kind of wool used in its manufacture. The quality of the fibre depends on the sheep. For this reason the shepherd who cares for the sheep has almost as important work to do as the manufacturer of the cloth. The sheep must have good food; they need to be protected from weather which is too hot or too cold; they must be healthy. When sheep do not receive proper care their wool becomes coarse and less silky.

Many kinds or breeds of sheep are raised for their fleeces. The finest wool comes from the merino sheep. This is so fine that forty thousand little hairs grow in one square inch of the sheep's coat. The fibres are very kinky and are rarely more than four inches long. There are several varieties of the "long-wool" sheep. The fibres from their fleeces are coarse but because of their length they are easy to spin into yarn.

Sheep are usually raised in great flocks in countries where they can graze on large grass-covered plains. Once a year — in warm countries twice a year — they are driven into the shearing pens and here their fleeces are cut off. Nowadays the shears used for the cutting are run by electricity and one man can shear from one hundred and fifty to two hundred sheep in a day. He catches the sheep, one by one, and holds them very tightly while he does the cutting, so as not to cut the skin. The poor sheep make a great deal of noise with their bleating and baaing, so that a shearing-pen is a very noisy place. The little lambs are sometimes shorn, too, as their fleeces are very soft and fine. They look very comical when their coats have been cut off, and no doubt feel very much ashamed. By the next

shearing-season they have forgotten all about their sad experience and make as much noise as ever.

In spite of all that a shepherd can do, his sheep naturally become dirty. Good fleeces are oily, as the sheep's skin secretes oil through its pores for the purpose of keeping the hair soft. So the fleece catches a great deal of dust and dirt, and of course every burr in the pastures sticks to the fuzzy coat if it gets a chance. The first thing which must be done when the fleeces reach the manufacturer is to clean them. The wool is sorted and those parts which are too coarse or too dirty to be cleaned well are set aside for cheaper grades of cloth. The wool is then put through a scouring-process in huge tanks of warm soapsuds. Sometimes gasoline or ammonia is also used for this cleaning. The tanks are fitted with rakes to push the wool back and forth in the water, and with rollers to wring out the suds. If the cloth is to be colored, the wool-dyeing usually takes place just after the scouring. After the wool has been dried by machinery the burrs are picked out by means of another machine. If the wool does not yet seem clean enough it must be carbonized or soaked for several hours in a mixture of acids and water. The acid eats up the burrs and other bits of dirt clinging to the wool but leaves the wool fibres themselves uninjured.

After all these things have been done you can imagine how matted and tangled the fibres must be. They are sent through a machine which picks them apart and sprinkles them with olive oil to make them soft. They are then ready for spinning and weaving. These processes are much the same in the making of other kinds

of cloth. Some cloths made from sheep's wool are called woolens, while others are called worsteds. The difference is that for worsteds the fibres are straightened and laid parallel and then well twisted in spinning, while for woolens they may lie crossed and intermixed. The worsted used for some kinds of knitting and embroidery is, on the contrary, very slightly twisted. Worsted fabrics are generally smoother than woolens.

Many names are given to different kinds of woolen materials. Cashmere is made from the wool of a goat in Thibet. Alpaca comes from the hair of the South American animal by that name. Mohair is made from the long silky hair of the Angora goat. Shoddy is made from old woolen rags and waste materials which are ground together and respun into yarn for weaving.

Man has used wool for a very long time. The ancient Romans were skillful in spinning wool and weaving woolen fabrics and they taught the craft to the people of northern Europe. England, which leads the world in the manufacture of beautiful woolen materials, first learned the art about 400 A.D. from some Roman soldiers who established a weaving factory at Winchester, England.

IMITATING THE SILKWORM

SINCE man has been studying the science called chemistry he has discovered many wonders. He has learned how Nature makes many things and, after trying over and over again to imitate the work which she does, he has succeeded in making many products almost as well

as Mother Nature can make them herself. These products we call "artificial" because they are imitations of natural things made by art.

It is not surprising that chemists have tried to imitate the work of the wonderful little silkworm. Silk, we have learned, is the strongest of all textiles, and because of its softness and its lustre or shine it is also the most beautiful. But it is expensive. Chemists have been trying for more than half a century to make an imitation of silk which would not be so costly. By means of their discoveries it is now possible to imitate real silk in several ways, but nothing has ever yet been found which is quite so beautiful.

For nearly all of these imitation silks, cotton is used in some way. Mercerized cotton looks much like silk but it is not so strong. When cotton fibres are soaked in a solution of caustic soda or caustic potash a peculiar change takes place. They swell in diameter and get shorter. This shortening process makes them much stronger, and the soaking changes them in some way so that they dye more easily. But this process alone does not make them look like silk. If the material, after having been soaked and washed, is stretched until the fibres are as long as they were before, it becomes shiny or lustrous like silk. Then, if it be washed in a solution of acetic acid, it will even rustle like silk. Mercerized cotton is used for making sateens, silkolines, and tub silks, and also for mixing with real silk.

Another way of imitating silk is to give cotton yarns a coat of real silk. This is done by dissolving silk remnants in some kind of acid and giving the cotton

fibres a bath in the solution. This coat of silk over the cotton does not wear well. The process can therefore not be used for cloth which is to be worn or washed much.

More wonderful than any of these processes is a third way of making artificial silk. By studying the sticky fluid from which the silkworm spins its threads chemists discovered just what it was made of. Since that time there have been many attempts to make a silk fibre as good as a natural one. The most successful artificial silk is made from cotton or from wood. Both these materials are largely composed of a substance called cellulose. When they are dissolved in certain acids or other chemicals they much resemble the sticky fluid of the silkworm. But how is this sticky substance changed into threads? It is placed in steel cans or cylinders and forced out by pressure through tiny tubes about the size of hairs. The little wet filaments are then forced into some other substance, such as weak nitric acid, which toughens them into real threads. After washing and drying they are ready to be spun and woven into cloth just as real silk fibres are woven.

Artificial silk is glossier than real silk; but it feels rougher to the touch and is not so soft and delicate. It becomes weaker in water, so that articles of clothing which must be washed often should not be made of artificial silk. It is used a great deal for making trimmings, neckties, curtains, ribbons, furniture coverings, and hosiery. Chemists are trying all the time to make better silk. By and by they may really surpass our little friend the silkworm.

NIMBLE FINGERS AND WONDERFUL MACHINES

HAVE you ever watched your mother making lace? You were no doubt surprised that her fingers could be so nimble and move so rapidly. Lace-making is a very old art, and in some of the countries of Europe it has been developed so highly that it seems impossible for the human hand to make anything so fine and delicate.

Perhaps women first learned to make lace by watching the spider spin its beautiful web. At any rate it has been used as a decoration for many centuries. Remnants of lace have even been found in some of the old Egyptian tombs. Lace-making did not become an important industry, however, until the Middle Ages. At first lace was worn more by men than by women. They used it for ruffles on their sleeves, for collars, cuffs, and scarfs; they even wore ruffles of lace at the tops of their high leather boots.

Handmade lace is produced by women all over the world, but only in certain countries is it made in large amounts to be sold. In France, Belgium, Spain, Ireland, and Italy one can buy marvelous laces if one wishes to pay the price. It requires such a long time to make really fine, beautiful lace that it must be costly.

Handmade lace is usually made in one of two ways and is called either needlepoint or pillow lace. For needlepoint lace the paper design is attached to a piece of heavy linen. Foundation threads are laid on the lines of the pattern and fastened also to the linen. Then with a needle and thread the complicated pattern

is filled in on the skeleton of thread. When it is completed the linen is cut loose. For pillow lace the design is fastened tightly to a fat, hard, little cushion. Pins are

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AT EIGHTY–TWO YEARS OF AGE SHE MADE POINT LACE FOR THE QUEEN

stuck into the pillow, following the outline of the design. The threads, of varying sizes if desired, are wound on little bobbins or spools and are woven in and out, twisting and crossing the threads to form the openings and the solid parts of the pattern.

Some handmade laces seem too beautiful for belief. Many of the old Belgian laces were so fine that the linen thread used had to be spun in a damp, cool cellar, as heat and dry air injured the fibres. The threads so spun were often so fine that they could hardly be seen by the spinners at all. The fingers of the women were so delicate and well-trained that they did their work entirely by touch. Surely lace made from this kind of thread was as exquisite as the spider's web.

After the stocking machine was invented people began to think of making lace also by machinery. The first machine-lace was made by a stocking-weaver after he had studied the lace on his wife's cap. Many improvements have been made since that time, and it is possible nowadays to imitate by machinery many kinds of handmade lace. Machines can work so much more rapidly than anyone can work by hand that it is now possible for all of us to buy lace at a low price.

Lace-making machines resemble looms for weaving cloth, only they are much more delicate. Warp threads are stretched on the machine just far enough apart for the edge of a silver quarter to be slipped through. This threading requires such care and skill that often two men must work at it for two weeks, some of the machines holding eight thousand warp threads. The crosswise threads, corresponding to woof in cloth, are carried in and out among the warp threads on tiny bobbins, so thin that they pass through without difficulty. For some laces that have a figured pattern, strips of cardboard are punched with holes that mark the shape of the pattern so that they look like player-piano rolls.

The strips are fastened together in a sort of belt or chain, which is then attached to the lace-making machine. The holes in the cardboard control the passage of the bobbins or needles which form the pattern in the lace.

Handmade lace is so much more beautiful than any made on machines that it is to be hoped our mothers will never forget how to make it. Special schools have recently been started in the United States, where it is possible to learn to make lace almost as lovely as that which comes from the fingers of the skilled workers of Europe.

PINS AND PIN MONEY

"See a pin and pick it up,
All the day you 'll have good luck."

THIS saying no doubt came from the fact that pins are so common and of such little value that it is a careful and thrifty person indeed who will bother himself to pick one up. It is said that not more than one pin in every hundred is worn out. All the other ninety-nine are lost.

But pins have not always been so cheap that one could afford to be careless with them. There was even a time when pins did not exist at all. Instead of them people probably used fish bones and stout thorns, or strings of leather for fastening their clothes. And yet metal pins have been in use a long time. Bronze and copper pins have been found in some of the old Egyptian tombs, some of them beautifully decorated with jewels.

Pins were not made in Europe before the fifteenth century. They were then shaped by hand from gold or silver. For this reason they were so expensive that

only rich people could afford to own them. It became the custom to give a bride money with which to buy pins, as one of her wedding gifts. Thus people came to speak of "pin money"—a term we still use, but with a quite different meaning. When pins were first made in the United States they were still rare, costing as much as a dollar for a paper.

In 1824 an American invented a machine for pin-making which so simplified the process that pins soon became much cheaper. And so many inventions and improvements have been made since then that now-adays pins are made entirely by machinery. They are even stuck into the papers by machine.

In the United States their material is chiefly brass wire. Some are made of iron, but those rust easily and are not so good. In England and Germany many pins are made of steel wire. Those can be much more slender and more sharply pointed and are therefore considered the finest. They are used a great deal by dressmakers as they do not punch such large holes in the materials.

The wire for pin-making comes wound on large spools. A machine draws the wire through a hole in a steel plate just the size of the pin desired. The end is struck by a hammer to form the head of the pin, the wire is cut into the proper length, and the pin falls into a groove where it hangs by its head. The opposite end is whirled between two rapidly moving rollers to form the point. The pins drop from the machine in a continuous stream, at the rate of from two hundred to four hundred a minute. They are then washed in acid to clean them,

and are rolled in sawdust or bran for polishing. They are given their bright silvery appearance by being boiled in a solution of tin.

A wonderful machine next arranges the pins in even rows, sticks them into the papers, and folds the papers into packages such as we buy in the stores. This machine is so delicate that a single imperfect pin will stop its running until the faulty piece is taken out. One machine can put one hundred thousand pins into their papers in a single hour.

Safety pins are made from the same materials as common pins, except that they are usually coated with nickel instead of tin. Steel safety-pins are given a double coat, one of copper and one of nickel, to prevent them from rusting. Safety pins also are made entirely by machinery, the caps or heads being cut and shaped by one kind of machine and the wires cut, pointed, and bent into proper shape by another. The heads are then attached to the wires by a third machine.

Pins of this kind were used many centuries ago. They were made by the Egyptians, as well as the Greeks and Romans, and were shaped much as they are to-day, but were made by hand from precious metals, such as gold or silver, and few people were so grand as to own one.

NEEDLE-MAKING

THE common needle, without which no hand sewing can be done, is one of the wonders of modern manufacture. Among primitive peoples needles were very crude, being made of bone, ivory, or wood. Since we

have learned to make needles of steel, the methods of manufacture have become more and more perfected. To-day the finely polished, shining little instruments pass through twenty-one or twenty-two different processes in their making.

Needles are made of the best steel wire, very finely drawn and highly tempered. The wire comes wound in coils, and is cut into the necessary lengths for two needles. The wires are collected into bundles, placed in iron rings, slightly softened by heat, laid on an iron plate, and rolled and pressed until absolutely straight.

The wires are then sharpened to a fine point at both ends, being held with a rubber band to a grindstone. Impressions for the eyes of the two needles are stamped on the wires, which are then passed to a screw press where the holes are accurately punched. Two wires are now run through the eyes and the two sets of needles are cut apart. After this process the rough needles must be filed until smooth; they must be heated and hardened in oil to be made tough and strong; they must be straightened, scoured, and polished; and the eyes must be cleaned. The final sorting by size and quality, the wrapping, and the labeling are done by hand.

Besides our ordinary sewing-needles there are many other kinds, each requiring slight variations in its manufacture. There are needles for the sewing machine, needles for surgeons, upholsterers, harness-makers, shoemakers, glove-makers, lace-makers, and an infinite variety of other hand workers.

THE SPOOL OF THREAD

ALL through the history of the human race man's needs have urged him to make new things. It has been said that "Necessity is the mother of invention," which is another way of saying this same thing.

In the story of sewing-thread we find this true just as we do when we read about baskets, brooms, buttons, and many other things that are common to-day. The first cave-woman who ever tied two skins together to make a dress no doubt felt the need of thread without knowing what she wanted. Savage or primitive peoples almost everywhere use strips of leather or animal tendons in place of thread. You can imagine how difficult it would be to sew with a strip of leather, or with a cord as large as the tendons which you see standing out at the front of your wrist. Many animal tendons are even larger than these. To sew with this kind of thread, holes must first be punched in the edges of the skins and the cord used for tying or lacing two skins together.

Thread is used in so many ways to-day that we can hardly imagine being without it. It is used in making shoes, hats, gloves, umbrellas, dresses, coats, and hundreds of other things. Because its greatest use is in sewing machines, thread has been made better and better as the sewing machine has been improved. The strongest threads are made for machine use, since the wear and tear on thread is much greater in the sewing machine than in hand sewing. You have noticed how the thread slides back and forth through the machine

needle many times in the making of a stitch. In fact the thread runs in and out of the eye about nine times before the stitch is completely made.

The first sewing-thread was of linen. It was made by hand and was sold in hanks or bunches, just as knitting wool is sold to-day. Threads are now made of the fibres of cotton, silk, and wool, as well as linen. The fibres are carded and spun just as they are for cloth-weaving, but these first-spun fibres, called "yarn," are too small and weak to serve in sewing. Two or more of them must be twisted together to secure greater strength. The best cotton thread is made of six such strands twisted together. This is called six-ply thread. Two strands are twisted together to make a small cord, and three of these cords are then twisted in the opposite direction to make the thread. The spinning and twisting are now done entirely by machinery.

Instead of being sold in hanks to-day our thread comes from the factory on spools. The making of the spools is one of the most interesting processes in the factory. One sees there great piles of wood cut into strips a few feet long and about two inches square. These are run through a turning machine which changes them into cylinder-shaped rods about the size of a spool. These rods are cut into sections of spool length, and sent to a boring machine where the hole is cut through the centre. Another kind of cutting machine scoops out a hollow around the centre of each spool, to make room for the thread to be wound. The spools are carefully sorted so that any imperfect ones, which would injure the thread, may be thrown

out. The good spools are then ready for the winding machine.

This machine is itself wonderful to watch at its task. It is provided with many spindles or little rods, each of which holds a spool. On each spool the thread is wound, a metal guide moving back and forth to wind it smoothly. When the spool is full the spindle stops moving and a metal finger moves across the spool carrying the loose thread. A knife then comes up and cuts a notch in the edge of the spool's end. Another finger catches the thread and pulls it tightly through the notch so that it will not unwind. The thread is then cut free and the spool is pushed off.

By means of another ingenious machine the labels are pasted on both ends of the spool at the same time. The labeling machine holds the spool, while two revolving pieces, shaped like wheels without rims, stick on the labels, both meeting the spool at the same time. One label gives the length and size of the thread and the other the name of the manufacturer. A spool may often carry two hundred, three hundred, or four hundred yards of thread.

RICH MAN, POOR MAN, BEGGAR MAN, THIEF

BEFORE buttons were invented dressing was no doubt a difficult process. Instead of buttons people used pins, tie-strings, sashes, and buckles to hold articles of clothing together. The idea of the button and buttonhole was not thought of until sometime during the fifteenth century. Probably only rich people could afford to wear buttons at first, as many of them were actually

jewelry, made of gold and silver, beautifully set with precious stones.

Buttons are now made of various materials. Many are of mother-of-pearl, the lustrous inside layer of oyster, abalone, and mussel shells. They are also made of vegetable ivory; of metals, such as brass, iron, and steel; of horn, bone, hoof, glass, porcelain, wood, celluloid, leather, and even paper which has been specially treated and is called papier-mâché.

Most of the buttons used in the United States are made from mussel shells found in the bed of the Mississippi River. The idea of using these shells for button manufacture occurred first to a man in Iowa in the year 1890. Before this our pearl buttons were made from sea shells and most of them had to be imported from other countries. More than fifty thousand tons of native mussel shells are now used annually for button-making.

Fishing for mussels has become a thriving occupation. The shells are gathered in large quantities by rakes, dredges, or tongs. The meat inside the shells is boiled and scraped out, both meat and shells being carefully searched for pearls, as valuable ones are often found inside such shells. The shells are then shipped to factories. Here they are sorted or classified according to size and quality, and are soaked several days for cleansing. Circular "blanks" — that is, button forms without the holes — are then cut from the shells by means of a machine which is provided with a hollow circular saw. The blanks are ground down to the proper thickness, are shaped, and drilled with eyes or

holes. They must then be polished in order to remove all roughness and to give them the proper lustre. The polishing is done by means of acids, or by the use of ground charcoal and turpentine. These processes are now all carried on by machinery. There is even a machine which will sew buttons on cards, after they have been sorted according to size and quality.

The vegetable ivory which is used for buttons comes from the nut of a palm tree which grows in South America. This material resembles real ivory, but it is softer and can be dyed to match various clothing materials. It is used largely for buttons on men's suits. The nuts are cut in halves and the buttons cut out by machinery. The processes of grinding, drilling, and polishing are much the same as those used for pearl buttons.

Glass buttons may be very beautiful, as glass lends itself so well to varied colors. Czechoslovakia was the special home of glass buttons, though they are now made in other parts of the world. They are usually made by softening with heat the end of a glass rod and pressing it into a mould of the desired pattern.

Cloth and silk buttons are produced by covering wooden or metal forms of the desired size and shape. This also is done by machinery, so that the cloth covering is smooth and firmly fixed. Ordinary shoe buttons are made of papier-maché. The material is thoroughly soaked with linseed oil and pressed by machinery into the proper shape. The buttons are then given several coats of varnish, hardened by baking, dyed, polished, and finally revarnished until smooth and shining.

When one thinks that even so small a thing as a button has perhaps come from some far-away part of the world, one realizes how many stories could be told just by the materials which go into our clothing. Your glass buttons have perhaps come from Czechoslovakia; the buttons on your winter overcoat probably grew in far-away South America; the pearl buttons on your other clothes may once have lived in the bottom of the ocean.

THE SNIP OF SCISSORS

More than three thousand years ago the Egyptians made scissors. Long before Christ was born the early Romans used them. Just how those early peoples made scissors we do not know, but they probably heated the metals which they used and hammered them into shape while still soft. The specimens and pictures of ancient scissors which have come down to us look much like our own.

Modern scissors are made in many forms and sizes. The larger ones, measuring more than five and a half inches in length, are called shears and usually have handles differing in shape, one made round to fit the thumb and the other oval to fit four fingers. Scissors are smaller and generally have both handles alike.

Iron or steel may be used for scissors-making; the quality of the tool depends on the method of treating the materials. The cheapest scissors and shears are made of cast iron. These are shaped by casting — pouring melted iron into forms or moulds which have been shaped like a half of the pair of scissors desired. Such tools are fit only for paper-cutting or simple work

which requires little strength and only fair accuracy. They break easily, and it is impossible to give them a really good, sharp edge for cutting. Cast-steel scissors are somewhat better, as steel is stronger than iron; but these also are hard to sharpen and the cutting edge soon becomes dull. One can usually tell scissors made of cast metal by the fact that the two halves are joined together with a rivet or metal pin instead of a screw.

The best scissors are made of a fine quality of forged steel. These are cut from a bar of metal by means of machinery. A heavy punch, shaped like a half of a pair of scissors, is raised and lowered upon a bar of steel many times until the material is cut through.

The so-called steel-laid scissors are almost as good as those of forged steel, and large shears are usually made in this way. The frame or main part of the scissors is made of a good grade of iron or steel, while the cutting part of the blades is of fine forged steel. The two parts are welded together — that is, they are softened by means of great heat and then by high pressure are forced so tightly together that they unite.

After the two halves of the scissors are cut and holes for the screws have been ground in, the pieces must be hardened and tempered so that they will not be brittle. This is done by heating and cooling the metal in special ways which toughen it. The grinding or sharpening of the scissor blade is extremely important. This is done by men sitting in front of huge grindstones. A good workman sometimes grinds as many as eight thousand blades a day, although he grinds only a special part of the blade. A new grindstone six feet across

wears away so rapidly with the constant grinding that it lasts only a short time.

After the grinding, the blades are cleaned and then passed through a nickel bath to give them the bright, shiny appearance which scissors usually wear. When the two blades have been put together they are carefully tested to make sure that the tool is perfect. They are oiled to keep them from rusting, and then wrapped and packed ready for sale.

The best forged-steel scissors are made in Germany, but the United States leads the world in the manufacture of steel-laid shears and scissors. One factory in the United States makes over five hundred kinds of scissors, including every size from tiny embroidery and manicure scissors to the large shears used by tailors and the enormous pruning shears used for trimming trees and shrubs.

THUMMELS OR THIMBLES

We may not think of thimbles as being so necessary to our comfort as soap, matches, needles, and many other things used in our daily life. But mankind must have felt the need of thimbles in very early times, for they were in use by the Chinese many thousands of years ago, and they have also been found in the excavations at Herculaneum.

In Europe thimbles were first used during the Middle Ages, but they were scarcely what we should call by that name. They were made of leather and worn on the thumb. This shows the reason for their name; in fact, many years ago they were called "thummels" instead of thimbles. In the sailmaker's thimble used

to-day we can still see a kind made to be worn about the thumb. It is a leather band around the hand, with a hole for the thumb; at the base of the thumb is fastened a metal piece for pushing the heavy needle which sailmakers use.

Metal thimbles were first made in Holland during the seventeenth century. They were shaped by hand and were sometimes of gold or silver. Occasionally one was beautifully decorated or jeweled.

Thimbles are made now by machinery and may be of celluloid, steel, aluminum, brass, gold, or silver. The process is much the same for all these materials. From flat sheets of metal round discs or blanks are cut. These blanks are pressed down by machinery into moulds the size and shape of the outside of a thimble, the inside of the thimbie being shaped by a solid core of metal which fits the inside of the shaped blank. The tops of the thimbles are then trimmed off and the edges curled over by another machine. The decorative engraving and the hollows for the needle-head are pressed in by means of a stamping machine. Brass thimbles are generally given a bath in a solution of nickel or silver, which forms a bright coat on the outside.

Celluloid thimbles are made from tubes of celluloid which are as large around as the desired thimbles. The tubes are cut into pieces, each long enough for a single thimble. These lengths are put into a heated press with a core for moulding the inside of the thimble and are pressed into the proper form. The little dents for the needle-head and the roll at the edge are formed by pressure in this heated mould.

PART IX

IN THE WARDROBE

FROM NORTHERN WOODS TO WARM FUR COATS

THE beautiful furs which are used the world over for clothing come mostly from animals that live in the North woods or in the Arctic regions. These fur coverings were given them for protection against the cold, and man learned very early that he, too, could keep warm with that kind of clothing. He began to use hairy and furry skins long before he learned to make cloth.

What tales a trapper can tell! His life is full of adventure as he seeks the fur for our coats, caps, and gloves. Yet the life of a trapper may be a lonely one, as he rarely sees other human beings during the long winter months which form the trapping season. Thousands of men make their living in this way. The trapper must know well the habits of animals, where they live, how and what they eat, and at which season of the year their fur is most beautiful. He hunts with a trap instead of a gun. He seeks out the home of the animal and places a steel trap somewhere near by, often baiting it with meat or some other food. He frequently buries it with leaves or branches, and he always sets it in such a way that all but the most clever

animals step into it before they know they are in danger. Countless numbers of large and small animals are caught this way every year. They are then killed and skinned and the furs are sold in near-by cities, whence they are shipped to other parts of the world.

The rarest and most beautiful furs come from seals, beavers, foxes, sables, and the little weasels whose

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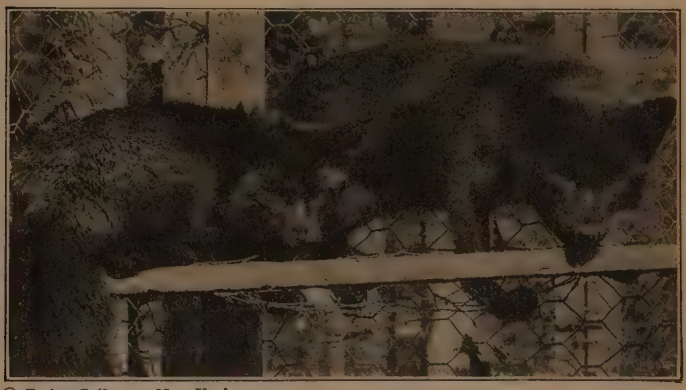
ALASKAN TRAPPER WITH DOG TEAM TAKING PELTS TO TRADING–POST

white coats make the fur called ermine. The skins of many other animals are much in demand, too. The muskrat, mink, mole, marten, opossum, wolf, and even the bear all have pelts which are considered beautiful. The coats of the rabbit and the common cat are used for some of the cheaper furs and fur trimmings. They are also used for making imitations of more valuable furs. Rabbit fur is even made to imitate sable, which is one of the rarest and most costly of all. Furs sold as seal-skin often come really from the common wild rabbit of Europe. The best furs are usually sold with their

natural coloring, so that one may feel fairly sure that a dyed fur is an imitation. The skin of an undyed fur is always whitish and the fur next to the skin is usually a brownish yellow or pale blue.

Before they can be used for clothing, furs must go through many processes to clean them, take out the animal odor, and make them soft and durable. These



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BLACK SILVER FOXES ON FUR FARM IN CANADA

processes are mostly carried on by machines which can handle several hundred skins at a time. After being dampened they are put into a tramping machine, which kneads them eight or ten hours to soften them. They are then usually soaked overnight in salt water and sawdust and are ready to be fleshed — that is, the bits of flesh or fat left clinging to the hide when the animal was skinned must be shaved off with knives. This is done by hand. After a good stretching and another beating they are ready to be cleaned thoroughly. This

is done in a big machine with revolving wheels which churn the furs about with sawdust to remove grease and dirt. After another beating, which removes the sawdust, the hair is combed and the furs are ready to be made into clothing. If they are to be colored, the dyeing takes place at this point.

Some animals are so small that hundreds of them are needed to make a single coat. Furs have become so popular and so many animals have been killed that many kinds are fast disappearing. Because of the danger of exhausting the supply of certain valuable fur-bearing animals many people are now engaged in fur-farming. That is, they are raising the animals as farmers raise hogs and sheep. The habits of the animals are studied so that they may be properly cared for, and they have homes as nearly as possible like their natural homes in the woods. Many foxes, minks, beavers, muskrats, raccoons, sables, and skunks are now raised in this way.

CHANGING FASHIONS IN SHOES

EVEN the most ignorant savage soon finds out that Mother Nature has not taken care of his feet as she has of the animals'. She has provided many animals with hair to keep their feet warm and with soft pads or tough hoofs to protect them from stones and thorns. But she has given man a mind which teaches him how to take care of himself. The savage soon learns how to protect his feet.

In warm countries the earliest shoes were sandals, made of strips of leather, wood, or woven grass to guard

the soles of the feet. They were attached by means of straps or thongs, which were wrapped and tied over the instep or brought up between the toes and tied about the ankle. In far northern countries the first shoes were no doubt made of animal skins, tied about the feet to keep out the cold.

By courtesy of the United Shoe Machinery Corporation

MOCCASINS OF THE AMERICAN INDIAN

Boots and shoes are still made of the skins of animals, but we have learned to change the skins or hides into smooth leather which wears much longer, is softer to the foot, and is much more pleasing to the eye. Hides are made into leather by a process called tanning. The skins of many kinds of animals are made into leather, but calf, sheep, and goat skins are most common in the manufacture of shoes.

When hides are received at the tanning factory or tannery, they are soaked three or four days in salt water for cleaning and softening and are then sent through a machine which cleans off all the bits of fat and flesh which may still be clinging to the skin. A thorough soaking in tanks filled with limewater loosens the hair and a scraping machine cleans it off. The hides must be washed again before the tanning process, as the lime, if left in, would eat the leather.

The tanning process is intended to strengthen the

leather, to keep it from decay, to make it more waterproof, and to take out the stiffness. The best method is to soak the hides in tanks containing tannin, an acid which comes from the bark of certain kinds of trees, particularly oak and hemlock. This process requires from ninety to one hundred days, which seems a long time to the shoe manufacturer who wishes to make shoes as rapidly as possible. A quicker method of tanning is now in use, by which certain chemicals are used in place of tan bark. This process serves for light, thin leathers, but for heavy leather, such as is needed for shoe soles or in harness-making, the older method is still followed. After the tanning the leather must be dried, oiled, and pressed to make it smooth and soft.

The many fashions in shoes which have been worn since early times would make an interesting story. The Greeks and early Romans used sandals, but the later Romans made foot-coverings of leather which more nearly resembled our own shoes. During the Middle Ages shoes became one of the most ornamental articles of dress, and one's social position was shown by the kind one wore. It became the fashion for elegant young men to wear very long pointed shoes, some of them so long that the shoe-tip had to be looped up and tied to the knee. A prince might wear a shoe thirty inches long; a baron might have his shoes twenty-four inches long; a mere knight must not exceed eighteen inches. Those early shoes were not accurately made to fit the feet and must sometimes have been very uncomfortable. It was not until about 1785 that a pair of shoes had a "right" and "left" and began to resemble the shape of the foot.

Many different kinds of shoes are worn in different parts of the world. You have seen pictures of the funny wooden shoes worn by the peasants in Holland, and you have heard about the tiny shoes of well-bred Chinese girls and women. Their feet are tightly bandaged when they are quite small children and never allowed to grow freely. If their shoes are more than three or four inches long they are thought to have very large feet indeed. Fortunately this custom is gradually ceasing to be practised in China, for it is cruelly painful; but in families of old-fashioned elegance it is still thought a great pity for a nice girl to have big feet like a common peasant or an American.

Before the sewing machine was invented shoes were made entirely by hand. It took a good shoemaker a whole day to make one pair of shoes. Shoes brought high prices and not everyone could afford them. In colonial times the shoemaker was a very important person. He often traveled from house to house, making and mending shoes for a whole family at a time. He also knew how to sharpen knives, cut hair, and pull teeth, so he could make himself very useful during his stay. Shoes were so scarce in those days that people took good care of the ones they had. Country children often walked barefoot until winter came.

Nowadays shoes are made almost entirely by machinery. A modern factory can make a single pair of shoes in fifteen minutes, although about one hundred and seventy different processes go into the making of one shoe. Almost every one of these processes is carried on by a different kind of machine. An ordinary shoe

By courtesy of the United Shoe Machinery Corporation

INTERESTING SHAPES AND VARIETIES OF WOODEN SHOES

has forty-four different parts, including the sole, uppers, heel, vamp or front part, tongue, laces, eyelets, and the many parts for the lining.

In the cutting-rooms the different parts are cut by machinery. But the cutters differ with each size of shoe and must be changed whenever the fashion changes. You can imagine what a busy time the manufacturer has, trying to keep up with pointed toes, rounded toes, long vamps, short vamps, high heels, low heels, straps, or whatever we demand in order to be fashionably dressed.

By many different machines the different parts are stitched together, a metal arch being fastened in the sole and stiffening put in the toe and heel to make the shoe keep its shape. The heels are generally made of layers of leather cemented together and are nailed to the shoes last of all. The shoes are then polished and the soles are sometimes rubbed with fine sandpaper to give a soft velvety surface. Fine shoes are then wrapped in tissue paper and each pair is put into a box. Other grades are packed in large boxes, several pairs together, and are sent to the shoe salesmen in that way.

The United States is now leading the world in the manufacture of shoes, the most important manufacturing centres being in New England. American shoemakers have learned to make more comfortable and more beautiful shoes than any others in the world. Over three hundred million pairs of boots, shoes, and slippers are made in our country each year.

MANY HATS OF MANY KINDS

It is not very hard to guess why hats were invented. We find the natives of nearly all hot countries wearing some kind of covering on their heads to protect them from the fierce rays of the sun. Perhaps the first hats were made from the leaves of some tree or shrub. You have probably shaped hats of your own from the large leaves of the rhubarb plant or by pinning together with their stems the leaves of the maple or oak. Hats have a history almost as old as that of man himself, for wherever we find a bit of history about man we always learn that he wore head-coverings of some sort.

If we were to make a trip around the world we should see many different styles of hats. In cold countries the people wear hoods or caps made of fur. The Eskimos have fur hoods made in one piece with their coats. In hot countries the hats are usually woven from some kind of grass or straw, but they are made in many queer and amusing shapes. In Turkey most men wear a fez—a kind of cap, shaped like a low flower-pot, with a bright-colored tassel fastened to the centre of the top. The Hindus wear turbans, made by winding yards and yards of cloth about their heads.

Even in our own country you can find many kinds of hats. In fact, women's head-coverings change their shapes and styles with every season. Most of our hats are made of either felt, hair, straw, or silk.

Felt hats are the most interesting of all. Most of them are made of fur; others are of wool or a mixture of fur and wool. The hairs of many animals are covered

with little scales, just like those of the sheep. Indeed, if you rub one of your own hairs between your fingers you will find that your finger slides down more easily than up. That is because the little scales point down. When hair is placed in hot water these scales loosen a bit, and several hairs, if pressed together, will cling closely to one another. This quality makes felt possible.

The hair of the European rabbit, called cony, is best for felt-making. The skins are first cleaned, and the hair is shaved off by machinery. It is then sent to a mixing machine which separates the hairs and makes them light and fluffy. Enough hair for one hat is placed in a machine inside of which is a metal cone about three feet high. This cone is filled with small holes through which air is sucked by means of a fan. Suction draws the hair to the cone and spreads it in an even layer over the surface. A damp cloth is placed over the hair and another cone is set on top. Both cones are then placed in very hot water, and by means of pressure the hairs are made to cling together.

The felt cone thus made is the beginning of a hat. It is shrunk by means of another bath in hot water, is dyed, given a bath in shellac to stiffen it, and then, by means of machinery and skillful handwork, it is gradually "blocked" over hat-shaped forms into the style desired. A stiff felt hat, or derby, differs from a soft felt in having a bath in stiffer shellac. After the shaping has been completed the sweat-band is sewed in, the binding around the brim is put on, and the hat-band, or trimming, is added.

Straw hats utilize many kinds of straw. The best comes from northern Italy where people raise a special kind of wheat particularly for hat straw. The stalks are pulled before the wheat is ripe, and are bleached either by lying outdoors in the sunshine and dew or by means of sulphur fumes in a closed chest. For most kinds of straw hats the straw must be braided into long, narrow, ribbon-like strips. Although machines for this purpose are in use, a great deal of braiding is still done by hand in several parts of the world. Many women and children spend most of their time braiding straw for hats. In little Italian villages they may be seen walking along the streets braiding straw as they go. The braided straw is then sent to hat factories.

In the factories the braids are usually stitched into hat shape by means of machinery, although Leghorn hats are sewed by hand so neatly that they look as if they had been woven whole. After the stitching the hats are stiffened with glue and are blocked into exact shape.

Panama hats are made from the leaves of a kind of palm-like tree which grows largely in Central and South America. The leaves are cut while young and are then split into long fine shreds, with the finger nails or with knives. After they have been bleached, the strips are woven into hats by the natives of the country. As the delicate material can be worked only while damp, it is left out in the dew every night and most of the weaving is done early in the morning or where the air can be kept moist. Some such hats, made of the finest strips, require several months of labor and command a large price.

Chip hats are made of long thin shreds of wood from the poplar or willow tree. The strips are braided and the hat is made like any straw hat. When it is completed it is usually given a coat of colored varnish to stiffen it and add to its nice appearance.

Silk hats are made on a foundation of muslin. Two or three layers of coarse muslin are placed together, soaked in varnish, and blocked into hat shape by the use of hot irons. The hat is then coated with another layer of varnish or shellac, and covered with silk or silk plush, a material which resembles velvet.

FROM GAUNTLET TO GLOVE

It seems strange that the wearing of gloves should have begun in connection with an old game or sport. In the Middle Ages the sport of hunting wild fowl or game birds was popular with grand people, both gentlemen and ladies. For this sport, certain species of hawks called falcons were trained to take part in the hunting. Every noble lord and gentle knight had his own falcon that perched upon his wrist as he rode forth to the hunt. The falcon's claws were sharp and the hunters soon learned to protect their wrists with gauntlets or long-wristed gloves.

Before that time gloves had not been in general use in Europe as an article of dress. They had been worn in cold countries as a protection against the weather and in some lands had been worn to protect the hands while doing heavy work. Even some of the ancient cave-dwellers had a queer kind of glove which was made of leather and sewed with leather threads, but those

were for protection rather than for decoration. After falconry — or hawking — became a sport in Europe, gloves soon became an ornamental part of one's formal dress, and people tried to outdo one another in the beautiful embroidery and laces on their gloves.

Our own gloves are now made of many materials, including leather, fur, silk, cotton, and wool. For leather gloves the skins of many kinds of animals are used. Lambskin and sheepskin are in most general use, but the skins of the deer, dog, calf, goat, kid, bear, fox, and beaver are also used. Lambskin is made to imitate the skin of the kid, so that most so-called kid gloves are really of lambskin. The very finest gloves are made of the skins of young kids that have been well cared for and fed on nothing but milk. This makes their skin particularly soft and beautiful.

Leather for heavy gloves is tanned like shoe leather, but for lighter, finer gloves a special process is used. After the hair has been scraped from the skins they are soaked in a custard made of egg-yolk, alum, flour, and salt. This queer mixture has been found to soften the skins better than anything else. The skins are then dyed — or rather painted, for the color is put on with a brush. After they have been dried they must be softened still more by a stretching and beating process called "breaking."

Many fancy finishes are given to glove leathers by special processes. Suède gloves are made from the inner side of a skin. For glacé kid the outside of the skin is used, but it receives a special treatment to make it glossy. The Mocha finish is given to leather by

rubbing the outer layer of the skin against an emery wheel to make it rough. Chamois is an inner layer of sheepskin. It is tanned with fish oil, which makes the skin washable.

For many years gloves were of course cut and made entirely by hand. One of the centres of the glove-making trade in Europe was at Perth, Scotland. About 1760 several families of glove-makers moved from Scotland to the United States and settled in New York State. One of the towns where they settled was named from their industry and is still called Gloversville. For several years they made gloves only for the people who lived in their own communities, but in 1809 a storekeeper made a trip to Albany, New York, on horseback, carrying with him a bag of gloves. He met with such success in selling the wares that he was encouraged to enlarge the business. He found farmers' daughters who would help him cut out the gloves and farmers' wives who would do the sewing. To this day a great deal of the sewing and stitching on gloves is done by women in their own homes. They live near the factories where the gloves are cut and embroidered.

Gloves are now cut by machinery, several pieces being cut at a time. From sixteen to nineteen different pieces are required for an ordinary glove, including the six gussets or side pieces for the fingers, a separate piece for the thumb, the front and back, the facings, and sometimes little triangular pieces at the base of the fingers. Great skill is required for stitching the gloves, as the pieces must be held exactly, yet not too tightly, during the sewing. It is specially difficult to sew in the

thumb-piece correctly. The stitching has been done on machines ever since the invention of the sewing machine. When the stitching is completed the gloves are sent to the "laying-off room." Here are tables equipped with many hollow brass hands of different sizes filled with steam. The gloves are fitted on the proper hands, and after a moment or two are taken off, well ironed, and looking trim and neat.

Fabric gloves, that is, those made of silk, wool, or cotton, are made on knitting machines. Some are produced by special machines which shape the glove as they work, while others are cut from flat pieces of knitted cloth and then stitched together.

KNITTING BY MACHINERY

ALTHOUGH stockings seem to us a necessary article of dress, they were one of the latest forms of clothing that man learned to make. They were first worn by people in the colder countries of northern Europe, but were quite unlike the knitted stockings we know to-day. They were made of skins or cloth, and at first were designed in one piece with the trousers.

Knitting looks much like weaving but is really very different. If you have ever watched your mother knitting you know that although she uses two needles she has but one long continuous thread or yarn which is wound on a ball. Weaving, as we learned when we read about cloth, is done always with at least two sets of threads, one forming the warp and the other the weft or woof. Whereas weaving is one of the oldest crafts known to man, knitting was not invented until

about 1500. It was first used in Scotland and probably the first knitted stockings were made there.

Many stockings are still knitted by hand, but if knitting machines had never been invented it would keep our mothers and sisters busy most of the time with their needles in order to keep us supplied with stockings.

The first knitting machine was invented in 1589 by an English clergyman, named William Lee. As he was anxious to have his machine patented and his knitting business encouraged by the government, he made and presented to Queen Elizabeth a pair of stockings. The queen was indignant because the stockings were of wool instead of silk, and gave him no help. He improved his machine so that it would use silk thread instead of wool and later sent to the queen the first pair of silk stockings ever made. She accepted them, but she failed to give him the help he needed. He worked for many years on his machine, both in England and in France, but he died in poverty.

Lee's machine was so made that there was a needle for each row of loops in the stocking. This is the principle on which the modern knitting machine is made But the original idea has been improved in thousands of ways, until now it is so complex and wonderful that it seems almost human when at work. The machines for knitting the finest stockings are provided with about twenty-one fine needles to an inch, and can make that many stitches per inch each time a row is knitted. Machines for knitting circular stockings were invented in 1816. Before that the stockings were knitted in a flat piece and seamed together on a sewing machine.

Most people still prefer stockings knitted in this way, believing that they fit better. These are called full-fashioned hose, while those knitted on the circular machine are said to be seamless.

It is interesting to watch one of the circular machines. It works very rapidly, making more than one million loops in five minutes. The machine is so made that the stocking will taper and fit the ankle snugly. Then the machine feeds in extra threads to reënforce the heel, shapes the instep, the sole, and the toe, and finally stops at just the right spot. The stocking is then sent to another machine which closes the open toe with a smooth, almost invisible seam.

The stockings are carefully inspected so that no imperfect ones may be sent from the factory. They are dyed, and finally stretched over metal forms heated by steam in order to shape and smooth the finished hose.

Many other articles of clothing are made on knitting machines to-day. Underwear, sweaters, gloves, mittens, scarfs, shawls, as well as silk jersey cloth and tricolette are made on special kinds of knitting machines. Some of these articles are knitted flat and are then stitched together by machines.

The first knitting machine in the United States was smuggled into this country in 1818, buried in a cargo of salt. England, in order to protect her knitting industry, had made it illegal to carry a machine away to another country. From this small beginning, with the little smuggled machine which was set up in Ipswich, Massachusetts, the enormous knitting business now carried on in the United States has developed.

A modern knitting machine can make one hundred pairs of stockings a day, while in the old days before the machine was invented it took a woman one whole day to knit a single stocking. A stocking factory to-day, equipped with hundreds of machines, can turn out many thousands of pairs in a few hours.

THE USEFUL RUBBER TREE

When Columbus, on one of his voyages of discovery, reached Haiti, he saw the natives playing with a ball which was made of a mysterious material unknown to him. The ball was soft and yet hard, and it bounced better than any ball he had ever seen. Your guess is correct. It was a rubber ball, and was probably the first article made of rubber ever seen by a white man.

Since that time, over four hundred years ago, rubber has become one of the most useful of all materials. From it are made shoes, coats, gloves, erasers, rubber bands, water bottles, automobile and bicycle tires. Its name is due to the fact that in 1770 an Englishman discovered that a piece of it would erase or rub out pencil marks. He at once called it a "rubber" and the name has never been changed.

Rubber is made from a juice which comes from certain kinds of trees and vines in tropical countries. Its chief source is a kind of tree which was found first in Brazil, where it grows in great numbers along the banks of the Amazon River. After several trials people learned how to raise the rubber tree in other countries and it is now cultivated in large groves or plantations in other tropical countries, especially in the Far East.

The juice is a milky substance which looks somewhat like that of the milkweed plant. It is contained in

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HOW A NATIVE OF JAVA TAPS A RUBBER TREE

slender little tubes just beneath the bark of the tree. When these trees are tapped by means of slits cut in

their bark the milky juice or latex runs out and is caught in the cups.

In South America the trees are tapped and the juice is collected by natives of the country. When they have carried the latex to their homes they change it into crude rubber. Outside their huts they build fires of sticks and burn the nuts of a palm tree which give off a black, oily smoke. Over the fire they set a kind of stove which looks like a jar without a top or bottom. The smoke pours out through this jar, and above it they hold a stick shaped like a paddle, which has been dipped into a bowl of latex. The heat and smoke thicken the sticky juice into a kind of dirty rubber. The paddle is dipped again and again into the bowl until a large lump of rubber has been formed. The lump is then transferred to a pole. Resting one end of the pole on a forked stick that has been driven into the ground, the workers add more and more latex, constantly turning it above the smoke until they have a large ball weighing several pounds. On rubber plantations of the Far East this native way of making crude rubber has been abandoned for better methods. The rubber is usually extracted from the latex in large pans by an acid process and when dried is shipped to factories all over the world.

In the factories the rubber receives different kinds of treatment, depending on the use to be made of it. It must always be cleaned, however, and this is done by mashing and rubbing it between hot metal rollers over which water is continually sprinkled.

Many years ago a man by the name of McIntosh

discovered that rubber would dissolve in naphtha, a substance somewhat like gasoline. It could then be

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DIFFERENT FORMS OF CRUDE RUBBER AT THE FACTORY

spread out and dried in thin sheets. These could be stitched between two layers of cloth, which were thus

made waterproof. Our raincoats made in this way are still called "McIntoshes" or mackintoshes.

Another man, named Charles Goodyear, made in 1844 a very important discovery — the process now called "vulcanization." Before that time rubber was affected by hot and cold weather, becoming sticky in summer and very brittle or breakable in winter. Goodyear learned that by mixing rubber with sulphur and keeping it at a fairly high temperature for a time it became leathery and would not be affected by ordinary changes in temperature. The use of this vulcanizing process has greatly increased the value of rubber, as it can now be used for many more purposes requiring hard wear in all seasons of the year.

Rubber boots and overshoes are made from sheets of rubber fastened over layers of cloth which have been rubberized or coated with a solution of rubber. The soles are made of thicker rubber sheets than the uppers. The pieces for the shoes are cut out by patterns and the two layers are put together. The different pieces are held together by a kind of rubber cement. The shoes are then dipped into a tank of varnish and sent to an oven to be vulcanized.

Rubber corks and pencil erasers are made by filling moulds with warm, softened rubber and pressing it into shape. Rubber bands are made by cementing a sheet of rubber into a tube, which is then cut into the desired widths. Rubber gloves are made from a solution of rubber dissolved in gasoline or benzine. A form shaped like a glove is dipped into the liquid and then allowed to dry and harden.

Rubber can be made very hard by adding more sulphur before the vulcanizing. Many things are made from hard rubber. It is used for fountain-pen barrels, pipestems, and combs, and for making many parts of machinery.

More rubber is now used for making automobile tires than for any other single product. Two-thirds of the world's yearly rubber-crop goes into rubber tires. Akron, Ohio, is the largest rubber-manufacturing city in the world.

LEAVES, PARASOLS, AND UMBRELLAS

CAN you guess how umbrellas were invented? If you have ever seen rhubarb stalks with enormous leaves two or three feet across, growing in the garden, you have a good hint. Perhaps you have even pulled these big leaves and pretended they were umbrellas.

In warm countries grow many plants with huge leaves like those of the rhubarb. Since tropical lands usually have bright sunshine most of the time, people learned to protect themselves from the sun's heat by carrying large leaves over their heads when they went walking. Then, because plant leaves soon withered, they began to make sunshades which were shaped like leaves but were of some material which would not wither.

Umbrellas were, first of all, parasols or sunshades. The handles were attached at the side, like the stem of a leaf, instead of in the centre, and they must have been rather inconvenient. They were probably first invented in the warm countries of Asia. In Greece

and Rome they were used by women of high rank, who usually had slaves to carry them. Men did not often use them.

People in England had never seen or heard of umbrellas until after 1700. For a time they were used only by ladies. Then a man named Jonas Hanway, who had traveled a great deal, came home from the East with a very large, gay-colored umbrella. He cared not at all if people laughed at him, and on rainy days walked about the streets of London carrying his big umbrella. At first people followed him in crowds, hooting and jeering and thinking him a great crank. But they could n't help seeing that he kept dry under his umbrella while they got wet. Other men followed his example, and after a while umbrellas became popular with them as well as with women. About the same time the book called *Robinson Crusoe* was written. People who read that story must have decided that Crusoe's umbrella was very convenient both in sunshine and rain. That, too, probably helped umbrellas to become popular. While they were still scarce in England, rain umbrellas were rented by the hour to students in the universities.

In a modern umbrella factory the steel ribs and stems are usually received from other special factories where those parts are made. The cloth for the coverings is also woven elsewhere, and is received in huge rolls, ready to be cut. In an assembling or gathering room the ribs and stems are put together, forming the frame. Men cut the cloth by hand and the pieces are hemmed and stitched together by girls at sewing

machines. The covering is then attached to the frame by hand sewing. The tips and the handle are glued on securely, and the umbrella is pressed, rolled, and put into a cloth tube or cover.

The handle of an umbrella may be of horn, wood, china, bone, pearl, ivory, gold, or silver. Many artificial substances are used now for making handles. Celluloid is used a great deal, as well as a new material called bakelite, which in its clear yellow state looks like beautiful amber. The cloth used in umbrella-making may be silk, cotton, wool, or a mixture of silk and linen, or silk and wool.

Many odd and interesting inventions have been tried on umbrellas. In 1776 an inventor produced one that was provided with a lightning rod as a protection in thunderstorms. The rod could be attached at the top, and a gilt cord connected this with a metal ball which trailed along on the ground. When not in use the rod and ball could be carried in the pocket. It is interesting to know also that umbrellas were used for the first parachute descents from balloons.

PART X

IN THE JEWEL BOX

THE POT AT THE END OF THE RAINBOW

GOLD has always been a sign of wealth and power. Men have fought and died to possess it. They have risked danger, hardship, and death to find it. Because it is rarely found in large quantities and the available supply of it is limited, it is called one of the "precious" metals. It has always been rare and valuable, and it is not strange that superstitions and legends have grown up about it. A huge pot of gold is said to wait at the foot of the rainbow. This pot of gold will make its possessor fabulously rich, but it is so far away and its exact location so mysterious that no one is ever likely to find it!

Gold has been used and enjoyed by all peoples. Its bright yellow color seemed to the savage like sunlight, and to them the sun was a sacred object. Gold does not rust and waste away like other metals, and it is so soft that it may easily be hammered or beaten into beautiful shapes. Man soon discovered these things about gold, and among the very earliest peoples it was used for making jewelry and other ornaments. In the tombs of the ancient Egyptian kings, which have been opened within recent years, are found lovely

examples of the work of Egyptian goldsmiths. In excavations made in Greece have been found beautiful golden cups, vases, pins, and brooches, which prove that even hundreds of years before the birth of Christ the jewelers' art was highly developed there.

Most of the gold used by these ancient peoples was found in Africa and India. Some gold was found in Asiatic Turkey. Crœsus, an old-time ruler over part of that land, is said to have been the first monarch to make gold coin. People still speak of an extremely wealthy person as "rich as Crœsus." Gold is to be found, in fact, in nearly every country of the world, and even in the water of the sea. It is most plentiful in South Africa, California, Alaska, Russia, and Australia. It is found in the form of dust or grains or nuggets mixed with the sand in the beds of streams, and in sand and gravel deposits left by rivers that disappeared long ago. It is also found mixed with other metals in rocks deep in the body of the earth.

The methods of gold-mining depend on the form in which the gold is found. Placer mining is used for the deposits found in the sandy beds of streams. This depends on the fact that gold is heavier than sand; when a mixture of gold and sand is washed with water, the gold sinks to the bottom and the sand can be poured off. This method may be used for small quantities of gold, and is called "panning" when the miner goes up and down the streams with his pan hunting for gold grains and nuggets. It is also used for work on a larger scale, when the sand or gravel is placed in a long trough or sluice through which water can run. In

some places hydraulic mining is practised. Where the soil in hills has been found to contain much gold, powerful streams of water are used to wash the soil in great quantities down into the valley. There it is run through a sluice so that the gold can be removed.

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GOLD–MINING BY WATER POWER IN NEW ZEALAND

When gold is found in veins of solid rock it must be dug out of the earth much as any other metal is mined. It is rarely found in a pure state in such mines, but is usually mixed with some other metal, such as iron, silver, or copper. In order to separate the gold, the ore in which it is found must first be crushed to powder by machinery. The next process depends on the fact that gold unites easily with mercury. The crushed powder is mixed with water and is passed over copper

plates coated with mercury. A great deal of the gold is caught in this way and is then separated from the mercury by a heating-process which causes the mercury to pass off as vapor. A great deal of gold remains in

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WASHING GOLD FROM ROCKS AND DIRT IN A SLUICE

the ore, however, and this is removed by the cyanide process. A solution of a chemical called potassium cyanide is passed over the ore. This dissolves the gold and so washes it out of the ore. The gold can then be taken out of the cyanide mixture by adding zinc shavings. The cyanide likes zinc better than gold, and by uniting with it leaves the gold alone. The pure gold which is thus procured is melted and poured

into moulds. When it cools and hardens it is called bullion. A few other methods are used for removing gold from ore, but these are the most common.

Pure gold is too soft to be used for most purposes, as it bends easily and is quickly worn away. It is therefore usually mixed with some other metal, such as silver or copper, to form an alloy. The color of

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BOX OF PURE GOLD AND PAN OF ORE FROM ALASKA

gold depends on the metal with which it is mixed, silver giving it a whiter color than its natural yellow, and copper giving it a reddish tinge. Pure gold is spoken of as 24 carat gold. When we speak of 18 carat gold, we mean that it has six parts alloy and 18 parts pure gold. The gold jewelry made by ancient peoples was usually of 22 carat gold. Most of the gold used in jewelry to-day is 14 or 18 carat, although even 10 carat gold is used for some jewelry. Our gold coins are made of 21.6 carat gold.

Because gold is so soft or malleable it can be hammered or beaten into extremely thin sheets called gold leaf. This beating is done by hand. The gold is placed between sheets of parchment or tough paper and is pounded with a heavy hammer. By means of a great deal of beating one ounce of gold can make 3360 little gold leaves, each so thin that 200,000 of them would have to be piled up to make an inch of thickness. Such gold leaf is used for gilding of all sorts. The golden domes on some great buildings are covered with gold leaf. It is also used for gilding the edges of book leaves and for making the gold letters on book covers. Dentists use a great deal of gold leaf for making fillings.

Gold is the most ductile of metals. That is, it can be drawn out into a fine wire without breaking. This fine gold wire is often used for making gold lace. It is wrapped about silk threads, which are then woven into the gorgeous lace used for decorating robes of state and military uniforms.

MOONLIGHT METAL

JUST as ancient peoples loved gold because it seemed to them like concentrated sunlight, so did silver seem precious to them because its shining whiteness reminded them of moonlight. The early chemists even called it "luna," which was the Latin name for the moon.

Primitive peoples did not discover silver so early as they did gold. Silver is rarely found as easily as gold. We have learned how gold is sometimes found in the shape of little grains or larger nuggets lying in the beds

of streams. Because of its brightness it was soon noticed. But silver is usually buried inside the earth and is found combined with some other substance such as lead, zinc, gold, or even sulphur. This silver mixture or ore looks rather uninteresting, being a kind of reddish or ash-colored earth. For this reason it was often overlooked and, as it was hard to find, it was considered even more valuable than gold.

Silver, like gold, is soft when it is unmixed with another metal, and it is easy to shape into beautiful forms. The old-time silversmiths or workers in silver did all their work by hand and learned to make jewelry and silverware so beautiful that modern craftsmen have never been able to equal it. They excelled in making lovely designs out of silver which were so delicate as to look like lace. This work is called filigree. During the sixteenth century the goldsmiths and silversmiths of Italy did such exquisite work that it is ranked with great art. Their cups, vases, candlesticks and other pieces of silver plate were sought by powerful kings and princes because of their great beauty.

Unfortunately many of those marvelous things have been melted into bullion and re-shaped into coin. During the Middle Ages people of wealth had a great deal of their riches invested in gold and silver vessels and ornaments. When a war occurred, for which they needed money, they often melted their gold and silver plate for that purpose. In this way we have lost much of the wonderful work of great artists.

To-day silver is the most common of the precious metals. It is found in several parts of the world, but

the most important mines are in Mexico, Peru, the United States, Chile, and Spain. The largest mine which has ever been discovered was found in 1850 on the eastern slope of the Sierra Nevada Mountains. This was called the "Comstock lode" or mine, being named for the man who discovered it. This man did not realize the great value of his mine and soon sold it.

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CLOSE QUARTERS IN A MEXICAN SILVER MINE

Silver ore is dug out of the mines with picks, hammers, and drills, and the silver is then separated from the other metals in the ore. It is harder to separate than gold, but some of the processes used are similar to those used for gold. Mercury likes silver as well as it does gold, so it is frequently used for separating this metal. The cyanide process is also used. This process depends on the fact that potassium cyanide will dissolve silver. The silver can then be taken out of the solution by using zinc shavings. When silver ore is mixed with lead the silver is separated in another way. The ore is melted and a current of air is forced through the mixture. As lead likes oxygen better than silver, it unites with the oxygen from the air and the silver is

left alone. When it is entirely freed from the lead it can be poured into moulds and allowed to harden, forming bullion.

Silver is attracted to sulphur and unites with it whenever possible, forming a black substance. This is the reason that a fork turns black when the yolk of an egg is allowed to remain on it, for egg yolk contains sulphur. The gas which we burn in our homes contains sulphur and causes silverware to tarnish, even when not in contact with it.

Silver, like gold, is both malleable and ductile: it can be beaten into thin silver leaf or drawn out into fine wire. A single ounce of silver can be drawn into three miles of silver wire.

TWO MILLION DOLLARS PER CUBIC FOOT

SINCE jewelers have learned how beautiful diamonds and other precious stones appear when set in platinum, our most expensive jewelry has been made of this rare metal. Platinum is the most costly of all useful metals, being worth at least two and a half times as much as gold.

This metal was first discovered about two hundred years ago in that part of South America called Colombia. It was thought to be an inferior kind of silver, because of its grayish-white color, and was named platina. *Plata* is the Spanish word for silver and *platina* means "little silver." Later platinum was discovered in Russia in large quantities; but for many years its real value was unknown. It was used in Russia for making small coins, and peasants even wore platinum buttons on their coats until about fifty years ago.

Some important things have been learned about platinum since that time. It does not melt until it is very, very hot — at least over 3092 degrees Fahrenheit. This makes it specially useful to chemists, as they must often work with materials at very high temperatures and have them in containers which will not melt. Acids do not like platinum and do not eat it so easily as they do most metals. This also makes the metal particularly useful to chemists. For the same reason dentists like to use platinum in making sets of teeth, as the acids in the mouth will not affect them. When platinum is mixed with a metal called iridium it forms a very hard alloy which does not wear away easily. This alloy is used a great deal for making the tips of gold fountain-pens. Gold itself would wear out much too soon to be used at the point of a pen. About one half of the world's supply of platinum is used by dentists and jewelers.

The total amount of platinum in the world is very small. Like gold, much of it is found in river beds where it has been washed down by rains and streams and deposited with the sand and gravel of the river bottom. It occurs mostly as small rounded grains or scales, although some rather large nuggets have been found. Platinum is found also in veins just like gold, and it is usually mixed with some other metal, such as iron, gold, or iridium.

The largest mines are to be found in the Ural Mountains in Russia, and in Colombia; but small amounts are found in the United States, Canada, New South Wales, and other places. Before the World War Russia

produced about ninety-five per cent of the world's yearly supply of platinum. Since the war shut Russia off from the rest of the world, many attempts have been made to find better mines in other countries. The United States needed platinum so badly during the war that the government forbade jewelers to use it, and asked people who owned articles made of platinum to give up as much as they could spare.

Since platinum has become so valuable its price has greatly increased. It is now worth $105 an ounce. A block of it measuring one foot each way would be worth about two million dollars. White gold is now used a great deal in jewelry work as a substitute for platinum. This is an alloy made by mixing gold with silver and nickel. It looks much like platinum, but it will not wear so well.

THE MOST VALUABLE TEETH IN THE WORLD

THE two long outside teeth of the elephant, which we call tusks, must seem to him very useful. He does his chewing with the teeth inside his mouth, but these long tusks, extending down the sides of his trunk, help him in a number of ways. He uses them for digging up the tree roots which seem to him such delicious food. When he is attacked by an enemy his tusks are useful swords. He finds them serviceable in carrying loads, for by means of trunk and tusks he can hold things very securely.

Unfortunately for the elephant, man has learned that these big teeth can be very useful to him also. It is

from the elephant's tusks that the world's supply of ivory is obtained. The best ivory comes from the African elephant and over seventy thousand of these animals are killed every year. Sometimes the tusks grow to be nine feet long and a pair of them will often weigh two hundred pounds. So you can see what an enormous amount of ivory is used in the world.

Besides the delicately carved ornaments in our jewel boxes many other things are made of ivory. Piano keys are covered with it. It is used for making billiard balls, knife and cane handles, combs, paper-cutters, chessmen, crucifixes, and many artistic ornaments.

Ivory has been used by artists for many thousands of years. Rude ivory carvings have been found even in the homes of the cave dwellers who inhabited Europe longer ago than anyone knows. Probably it was first used in India to make beautiful things, for that country is one of the homes of the elephant. Artists like to work with ivory because of its beautiful warm color and because it is easily carved and can be given a fine polish. In China and Japan the art of carving ivory has been most highly developed. The artists there make very tiny delicate things so finely carved that some of the work must be done with a microscope. From China have come the miniature ivory models of ships, houses, and gardens which we often see in museums. These seem to us too exquisite to have been done by human hands. Among the early Egyptians ivory was used a great deal, even for making or decorating furniture. King Solomon, about whom we read in the Bible, had a beautiful throne of ivory and gold. In Greece ivory was

used by the sculptors. Phidias made an ivory-and-gold statue of the goddess Athena or Minerva, for the most beautiful of all Greek temples, the Parthenon at Athens.

Fortunately for the elephants, there are many substitutes for real ivory. If all the piano keys were covered with ivory they alone would more than use up our yearly supply. But the teeth of the hippopotamus, walrus, whale, and wild boar are also used for smaller articles. Celluloid is a good substitute for ivory. There is also a kind of vegetable ivory which comes from the nuts of a South American palm tree. These nuts are almost as large as a hen's egg, and are used for making buttons and handles of various sorts.

There is still another way of getting ivory. In some countries, such as Russia, Siberia, Alaska, and China, are found buried in the earth the remains of elephants that lived and died thousands of years ago. These remains have in the course of time turned to stone and are called fossils. But the ivory has not changed, and it is just as valuable to-day as the tusks of the elephants still living.

It is fortunate that there are these ivory substitutes and fossil remains, for the time is probably not far off when elephants will be so scarce that they cannot supply the world's needs.

THE QUEEN OF GEMS

It seems hard to believe that the beautiful sparkling diamond is a near relative of coal. Because they are both forms of the same substance (carbon), coal is sometimes called black diamond. Of course they

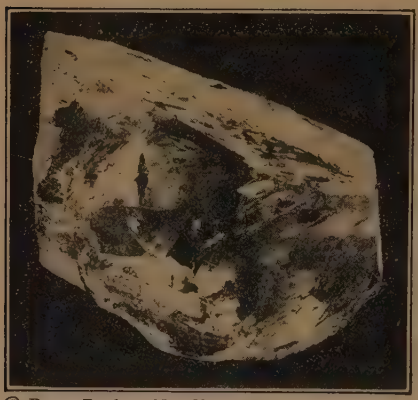
were made in different ways. Sometime during the earth's history the carbon of our diamonds was melted by terrific heat. It was subjected to enormous pressure of some sort while it was cooling, and it hardened in the form of the brilliant crystals which we value so highly as jewels.

Diamonds are harder than anything else in the world. For this reason the Greeks named them *adamas* — their word for "unconquerable." The hardness of the diamond makes it exceedingly useful in cutting and engraving other hard substances. Glass, precious stones, and even some kinds of rock are cut with diamond-pointed tools. For rock-cutting a cheap kind of diamond is used which would be of no value as a jewel.

Diamonds are usually found in the earth, where they must be mined, although some are occasionally found in the beds of streams, like gold nuggets. Few people recognize diamonds in their natural state or "in the rough," as we say. They are dull and rather uninteresting looking, and must be cut and polished to bring out their brilliance. They vary in size from small crystals about as large as a grain of wheat to the few which have been found as large as walnuts. The largest one ever found was as large as a man's fist.

Diamonds are usually colorless and as clear as a dewdrop, but they are sometimes tinged with blue, red, green, yellow, pink, orange, brown, or black. Diamonds "of the first water" — with the finest lustre — are most valuable; these are so clear that they cannot be seen in water. But blue, red, and green ones are also rare and therefore very valuable.

For a long time nearly all diamonds came from India, and many of the rarest ones now in existence are from the old East Indian mines. Later diamonds were discovered in Brazil, Borneo, Australia, the United States, and other countries. In 1867 the largest mines in the world were discovered in South Africa. Since that time most of our diamonds have come from there. The story of their discovery is interesting. A traveler one evening stopped at the home of a South African Boer farmer. He noticed that the children were playing with a strange-looking pebble which excited his curiosity. He offered to buy it, but the children laughed at the idea and gave it to him. This pebble turned out to be a very valuable diamond which was later sold in London for $2500. This traveler heard later of a queer stone belonging to a native witch-doctor, which was used to frighten away evil spirits. He visited the doctor and persuaded him to sell it for five hundred sheep and some horses. This was a large diamond and the man soon sold it for $56,000.



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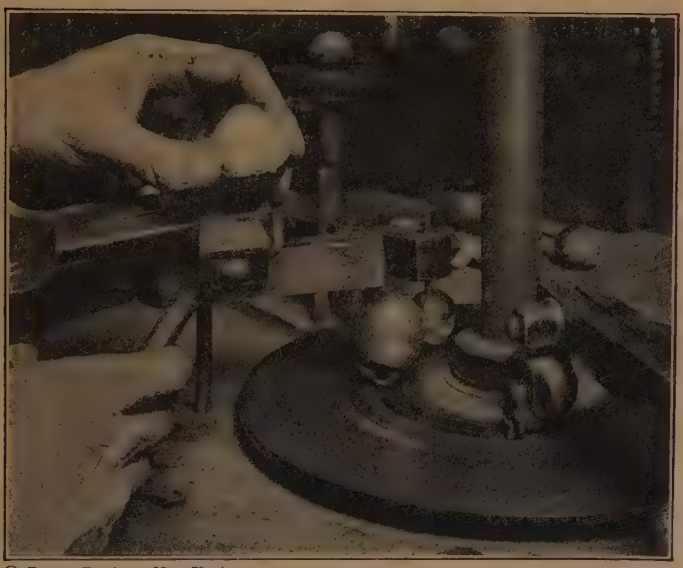
CULLINAN DIAMOND, LARGEST EVER FOUND

The news of these stones in South Africa spread rapidly and soon hundreds of diamond mines were

opened there. The African diamonds are found quite deep in the earth, embedded in a kind of hard blue clay. The rock is blasted by explosives and is hauled to the top of the mine by machinery. It is then spread out to lie in the open air for six months or a year, so that



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CUTTING THE POLISHED FACETS OF DIAMONDS

it may be loosened by the action of the weather. The earth is then washed off by machines which separate the diamonds and other heavy material. The diamonds are then sifted according to sizes and sorted into different grades.

The cutting and polishing of diamonds is work requiring expert skill and care. The cutting and grinding

are done by rubbing one diamond surface against another, as no other material is hard enough. During the grinding a great deal of diamond dust falls from the stones. This is carefully saved to be mixed with olive oil and used in polishing the gems. The stones are cut so that they may reflect the light in as many ways as possible and thereby increase their brilliancy. One modern method of cutting gives a diamond fifty-eight little polished sides or facets, each of which

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THREE GREAT STONES CUT FROM THE CULLINAN DIAMOND

catches and reflects light. And a diamond's facets do more than reflect light; they break part of the light up into the most exquisite gleams of rainbow colors.

Most diamonds which we see in rings weigh from one half to one carat. The largest diamond ever found weighed over three thousand carats. This was called the Cullinan diamond. It was cut into nine large stones and several small ones. The largest of these stones, called the Star of South Africa, still surpasses all other known diamonds in size, weighing over five hundred and thirty carats. These stones all belong to the

King of England. The largest is mounted in his sceptre and the second largest is in his crown.

If we knew all the stories which are connected with the famous diamonds of the world we could fill a large book. Another celebrated gem among the English crown-jewels is the Kohinoor. This has a very ancient history. No one knows how long a story it could tell as it may be five thousand years old. It once belonged to a great Indian prince, but was carried off as booty in war. Many times it changed hands in India and in Persia, and it might tell many a tale of war, murder, and intrigue, could it only speak. When the English conquered India they took possession of the famous diamond and presented it to Queen Victoria.

It is estimated that all the diamonds now owned in the world are worth about three billion dollars — a sum larger than we can imagine. Most of the finer ones are in museums or in the possession of royal families.

THE ARISTOCRAT AMONG GEMS

THE tiny pearl in your friend's finger ring may once have been a next-door neighbor to the sponge in your bathroom. Or it may once have lived in the very shell from which the pearl buttons on your clothes were made.

You know how uncomfortable it feels when a stray bit of dust or cinder gets into your eye. This is the way the pearl oyster feels when a little grain of sand or some other substance gets inside his shell. He feels irritated and nervous, no doubt. So he at once begins

covering up the bit of sand with thin layers and more layers of calcium carbonate and other chemicals which he gets from the water around him. By and by, instead of a common grain of sand he has inside his shell a wonderful satiny pearl.

Oysters, as you know, live on the floor of the ocean. Not all oysters make beautiful pearls. The largest pearl-oyster beds are in the Persian Gulf. Others are found off the coasts of Australia, Ceylon, and the Philippine Islands. The oysters which we eat produce no pearls that are of value as gems; but certain mussels that live in fresh water and furnish so many of our pearl buttons often form very lovely pearls.

Pearl oysters live from fifty to one hundred and fifty feet beneath the surface of the ocean, and can be obtained only by diving. They are usually found in the same neighborhood with colonies of sponges and with coral reefs. We learned how important the diver is to the sponge industry. He is even more important in pearl-fishing, because pearl oysters cannot be obtained by dredging and harpooning. A diver can usually gather about two hundred oyster shells a day. Not all these contain pearls, but some may, so the opening of the shells is very interesting and exciting. At any time one which will hold a pearl worth thousands of dollars may be opened.

The best pearls are our most costly gems. Their value depends on their lustre, color, shape, and size. The lustre or satiny gloss of the pearl is caused by the very thin layers of hard material which the oyster has built up about the grain of sand; they are somewhat

like the layers of an onion. The thinner and the more numerous the layers are, the more valuable is the pearl.

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CEYLON PEARL FISHERS COMING INTO PORT AFTER DIVING FOR PEARLS

Some rare pearls have more than eighty layers. Only an expert can correctly judge the excellence of a pearl.

The finest are pure or creamy white, or else a delicate rose-pink. They are sometimes found in other colors also, such as purple, yellow, or black. Black ones are particularly rare and for this reason are specially valuable. They are found chiefly in the Gulf of Mexico and off the coast of Lower California. Pearls vary considerably in shape and size. Round ones are most highly valued and pear-shaped ones are next in value. Oval or egg-shaped pearls are frequently found. Very irregular ones, called baroque pearls, are most common. The smallest are called seed pearls. They usually arrive at the market bored and strung in bunches, ready to be used in jewelry and trimmings.

Pearls are rather soft and the surface will wear away unless they are well cared for. As they are injured by hot water, a pearl ring should always be taken off before washing the hands. Some people cannot wear pearls at all, as the gems crumble and fall to pieces. This may be due to the fact that these people secrete an acid perspiration, for acids are extremely injurious to pearls. A pearl's lustre sometimes becomes dull if it is laid away for a long time. A dull pearl can be brightened by peeling off the outer layer or skin, but this is very delicate work and can by done only by an expert.

Among ancient peoples pearls were highly valued. The Chinese probably used them two thousand years before the birth of Christ. Some early peoples believed that pearls were angels' tears. Others thought that the oysters fed on the dew from heaven and that this dew changed into pearls.

In some places to-day pearls are cultivated artifi-

cially. This is done by inserting inside an oyster's shell a piece of foreign matter, such as a tiny bit of shell or mother-of-pearl. The oyster is then put back into the sea and at once begins to cover the uncomfortable

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PEARL DEALERS IN CEYLON WEIGHING AND MEASURING THEIR PURCHASES

spot with the pearl-making skin. In a few years a pearl has been formed and can be cut from the shell. Pearls made in this way are not so valuable as real ones, but they are often quite beautiful and can be used in jewelry where the flat side — which was attached to the shell — will be covered up.

Imitation pearls are now made in large quantities. A fluid is prepared by dissolving fish scales of a certain kind. Small glass beads are then dipped into the fluid, so that both inside and outside are coated with it. They are then filled with wax, and if carefully made can scarcely be distinguished from real pearls except by an expert. So-called indestructible pearls are made in much the same way, except that the inside is of solid enamel.

HOW MOTHER NATURE USES HER PAINT POT UNDERGROUND

MOTHER NATURE is fond of gay colors. Have you ever observed how lavishly she uses her paint pot? She throws a dazzling blue curtain across the sky, and for variety plays with the sunset like a dancer with many-colored veils. She covers the earth with green; then, lest it grow weary of an emerald gown, scatters dyes of scarlet, purple, and gold through the autumn fields and woods. On the flowers and birds she lets her imagination run riot, and never wearies of showing a new color which she has mixed in her paint pot. Underneath the ground she is not satisfied with dull-looking brown earth, but stores all the colors of the rainbow, and many more besides, in the gorgeous stones and gems which she keeps in her subterranean treasury.

The precious stones which we prize so highly and which have been used by man for personal adornment for so many ages have been made by Mother Nature in the red-hot furnace which she keeps inside the earth. They were made, like the rocks, by mixing together

various chemicals and treating them with great heat and pressure. You would never guess that the beautiful blood-red ruby is made chiefly of aluminum. Sometime in ages past this aluminum was mixed with oxygen and a bit of chromium from that paint pot, and the result, after a long period of great heat and slow cooling, was the dazzling ruby.

The sparkling blue sapphire is made of the same substances as the ruby, but some slight difference in the manner of its making gave it the different lovely color. The purple amethyst is a first cousin to ordinary quartz, the difference being that a bit of iron peroxide from the paint pot was added to give the color. By other combinations of plain-looking chemicals and mineral dyes most of our wonderful gems were produced. We have the brilliant green emerald, which is more valuable than the diamond; the sky-blue turquoise which looks like a small satiny robin's egg; the amazing opal with its dazzling play of colors due to tiny invisible cracks in the stone; the golden topaz which looks like imprisoned sunlight; and all the vast family of gay-colored stones.

These precious stones are found in many countries all over the world. Occasionally some are discovered mixed with the gravel in stream beds — the ruby and the sapphire. Others must always be mined from the earth, where they are found embedded in other kinds of rocks. The finest rubies come from Burma. Large, perfect ones are very rare. One ruby weighing three or four carats is worth a great deal more than a diamond of the same size. More than half the world's

supply of sapphires comes from Siam, though many are found in our own Montana. The finest amethysts come from Siberia, yet many are found in Brazil and the Ural Mountains. The costly emerald occurs chiefly in Colombia, South America, but it, too, is found in Siberia and other countries.

Because of the beauty and rarity of precious stones, which ancient peoples could not explain or understand, many superstitious beliefs have been connected with them. The ancients believed that each month of the year was under the influence of a special stone, which aided in warding off disease and danger. This gave rise to the idea of wearing birth stones. Special beliefs were associated with particular stones. The ruby, it was thought, would drive away sadness, evil thoughts, and bad dreams; the sapphire would pacify one's enemies, help to have one's prayers answered, and win the favor of one's superiors; the turquoise would ward off falls and bruises; the amethyst would prevent drunkenness; and by placing an emerald under one's tongue the gift of prophecy would be secured. Many superstitions have been connected with the opal. Until the seventeenth century it was considered a lucky stone, but for some strange reason it has since been fancied to bring ill fortune. Queen Victoria was very fond of the fire-like opal and since her time it has become more popular. Many ancient people believed that the opal, if wrapped in a bay leaf, would make its possessor invisible. For this reason it was thought to be a special friend of thieves.

Most precious stones must be cut and polished to

bring out their brilliance and beauty. A gem cutter is called a lapidary. A great many secrets exist among the lapidaries, as they know and guard carefully special methods of bringing out the glow and sparkle of various gems. They work with tiny saws, grinding wheels, and other special tools, and use diamond dust, finely powdered emery, putty powder, or rotten-stone for polishing.

Many imitations of precious stones are made, and some are so well done that only an expert can distinguish them from real gems. Rubies and sapphires have been successfully produced by chemists in their laboratories. Since they know just the chemicals which are found in these stones, they put the proper amounts together and fuse or melt them in small electric furnaces where a terrific heat can be obtained. Such artificial stones are often beautiful, but they lack the fire or brilliance of the genuine ones. So-called "reconstructed" stones are made by fusing together tiny fragments of the real stones; new ones so obtained are often quite lovely. "Paste" gems are imitations of precious stones made from a very fine grade of hard, clear glass, to which various coloring matters have been added to obtain "emeralds," "rubies," "amethysts," and so on. The cheapest jewelry is often decorated with ordinary colored glass.

GARDENS OF THE SEA

We have learned how thousands of years ago myriads of little sea-creatures lived and died, leaving their tiny shells or skeletons to form the chalk which we use in

our schoolrooms. We learned, also, that much of our limestone and marble was made of the shells of sea animals that lived ages ago. Just as wonderful things are going on to-day, for there is another kind of little sea-animal at work in countless thousands, making the coral which we wear in beads and brooches.

This "polyp," as it is more correctly called, is a marvelous creature. It is very tiny, but many polyps live together in a sort of colony. Each one secretes or throws out from its body a kind of limy substance, so that their common home is firm and solid. The founding of a colony starts from one tiny egg. When this hatches the creature swims or floats about for a while until it finds a rock, a piece of dead coral, or something hard to which it can attach itself. Here it settles down and never again leaves home. It soon begins to send out buds which are really baby polyps. These all live in the same colony, secreting lime. As the old ones die, their limy skeletons furnish a place for new polyps to live. Sometimes a single colony goes on increasing for hundreds of years and becomes very large. New colonies are started from eggs that hatch from the parents. When the rock-like accumulation becomes piled high enough to project out of the sea water it shows as a reef or an island.

The colonies in which these little coral polyps live vary a great deal in shape, as the polyps belong to different kinds of families. Some are shaped like beautiful flowers, others like cups, vases, fans, sponges, and horny shrubs. The organ-pipe coral is made of hollow tubes growing side by side, so that they look

like the pipes of an organ. Many thousands of these beautiful shapes growing together in the sea make one of the most beautiful under-water gardens you can imagine.

Corals grow in warm clear sea-water, so are found only in warm climates. They are found in the waters of the Mediterranean Sea, in the Indian Ocean, and in the Southern Pacific. Off the eastern coast of Australia they have formed a great reef over a thousand miles long. They are found off the coast of Florida, the Keys being made almost entirely of coral. Coral reefs shaped in curved ridges often shut in quiet lagoons or harbors, which make safe places for ships to anchor. Some corals form circular islands shaped like huge doughnuts. These are called atolls. The water surrounding such atolls is sometimes three hundred feet deep, showing what a long time these little creatures have been building up from the ocean bed to reach the surface of the water.

Coral is used a great deal for making beads, brooches, cameos, and other ornaments. It is easily carved and takes on a beautiful lustre when polished. The chief centre of the coral industry is in Italy, as this country lies near the great coral beds of the Mediterranean. There are several colors to be found in coral, ranging from white to deep red. The red coral is most used for making ornaments, but the rose-pink is considered the most beautiful. Rose-pink coral may be worth $400 an ounce. Some coral is almost black, but this is very rare.

Coral has been in use a long time for ornamental

purposes. In olden times coral beads were always worn by children, as it was thought they would keep away danger. Very beautifully carved pieces of coral are found in many museums, sometimes shaped like flowers, birds, and insects.

TEARS OF THE HELIADES

An old Greek story tells how Phaeton, the son of Apollo, the sun god, once tried to drive his father's flaming chariot in its daily course across the heavens. The great horses of Apollo were much too spirited and powerful to be controlled by a mere boy like Phaeton. They broke from his control and ran away. In their mad dash through the skies they set the earth on fire, terrified the moon, and would probably have destroyed some of the stars, if Jove had not hurled one of his thunderbolts and killed Phaeton. The three little sisters of Phaeton, called the Heliades, mourned his loss deeply, and as a punishment from Jove they were turned into poplar trees on the bank of a river. Their tears continued to flow, however, and these tears, as they dropped into the stream, turned into the beautiful beads which we call amber.

That is a pretty story which we should like to believe if we did not know more about amber. To the Greeks, and indeed to all ancient peoples, amber was a mysterious substance, the origin of which was unknown. The merchants who sold amber kept their secret well; they did not tell where they found it. When it is rubbed amber becomes electrified and will act as a magnet. It was from the Greek name for amber that

our word "electricity" came, for they called it electron. This magnetism seemed so strange to the ancients that they believed amber possessed many wonderful powers. Amber beads and ornaments were worn as a charm against evil spirits and witches. They were thought to ward off certain diseases, particularly throat troubles. A special kind of wine, which contained dissolved amber, was supposed to bestow the gift of immortality. Among some peoples a bride always received a string of amber beads on her wedding day. The beads were supposed to cast such a charm upon the bride that she would never lose her husband's love.

The first time you picked up a piece of amber you were probably surprised. You expected it to feel like the glass which it resembles. Instead, you discovered that it is much lighter than glass and has a softer feel. Amber is really the resin from pine trees which lived thousands of years ago. As the ages passed it became covered up with layers of sand and soil and changed somewhat in character. It is a hard, brittle substance, usually transparent like glass, and varies in color from a pale straw-color to a deep orange. It is found in largest quantities on the shores of the Baltic Sea. Ages ago, where the Baltic is now located, there must have been a great pine forest, for amber exists in great quantities in the soil beneath this sea, and often after a great storm the waves wash pieces ashore. Mines for digging amber out of the earth also exist along the coast of the Baltic. The best deposits are found about one hundred feet below the surface of the earth. The substance is usually in small pieces, but large lumps

have been found, weighing as much as ten or twelve pounds.

The most valuable pieces of amber are those in which insects are buried. When pine resin is fresh it is sticky and holds fast any insect that chances to get a foot fastened in it. In some of these pieces of amber are found the remains of insects which lived so long ago on the earth that none like them can be found to-day. Some of them look very beautiful imprisoned in the clear amber, and add greatly to its value.

Besides being made into beads, amber is used a great deal for pipe mouthpieces and for jewelry. The Turks and Armenians excel in amber work and are skillful in carving it into delicately beautiful ornaments.

A substitute for amber has been recently invented. This is called bakelite and is made of two chemicals called carbolic acid and formaldehyde. The substitute greatly resembles amber, and it is now being used for making pipestems, beads, umbrella handles, and other ornaments.

THE ROMANTIC HISTORY OF THE RING

LONG before man learned to believe in God he looked upon the sun as the most wonderful thing he knew. From it came light and heat. It was faithful to him, returning each day to change darkness into light and bringing him the seasons in regular succession. To him it meant power, protection, fidelity, dignity, and truth, and he made it an object of worship.

It was from this early worship of the sun that the circle came to be a sacred sign, standing among primi-

tive peoples for the good qualities which the round sun possessed. Among all savage peoples and even in the oldest caves of primitive man are found circles made of metal. In early times they stood for worth and value, and were used as money. Among savage people of all ages and countries they have been used for personal adornment. We find them worn as pendants in the lips, ears, and nose, and as bands on the wrists, ankles, and toes.

The custom of wearing rings on the fingers probably originated with the early Egyptians. The Egyptians were perhaps the first people to use seals for signing or sealing letters and documents. The writing in those early times was generally done by a secretary or scribe and the letter or document officially signed with a seal, as no one but the scribes knew how to write. The seal was carved or engraved on some precious stone and bore a design or picture which stood for the owner's name or title. In order to have the seal in some convenient spot, and also to keep it in a safe place where no one else could use it, the custom arose of attaching it to a ring to wear on the owner's finger.

The wearing of rings simply for decoration was but a short step from this. Egyptian women wore rings in great numbers and the jewelers invented many strange and lovely designs to please them. Many legends and stories are told of Greek and Roman rings. There is the story of the Greek ruler, Polycrates, who was so fortunate and so rich that he feared the gods might punish him in their envy. To appease their wrath he threw into the sea his most precious possession,

a magical emerald ring. Soon after, his cook came bringing him the ring. It had been found inside a newly caught fish. Polycrates then felt sure that the gods were not angry, and henceforth he enjoyed his good fortune in peace.

Rings were worn extensively among the Romans. It is said that after the great battle of Cannæ the soldiers of Hannibal gathered up on the battlefield three bushels of rings. Many Roman rings were heavy and cumbersome, so that the custom arose of wearing lighter rings in summer than in winter. Hollow rings which could be filled with poison were sometimes worn by important personages. When Hannibal saw himself in danger of being taken prisoner, he died by poison from his ring rather than become a slave.

The custom of giving a betrothal or engagement ring is a very old one, as the ring stood for faithfulness and purity. It was worn on the third finger of the left hand, because people believed that a vein led directly from that finger to the heart. Among the Romans a ring bearing a key was given to the bride on her wedding day. By this the husband showed that he was turning over to her the keys of his household. So numerous are the quaint and curious customs connected with finger rings that many interesting books have been written on this subject alone. Various materials have been used for making rings — iron, bronze, brass, gold, silver, bone, ivory, porcelain, and even stone. Often a person's social rank was signified by the material of which his ring was made. To-day our rings are generally of silver, gold, or platinum.

They may be made by soldering together the ends of a drawn wire, by stamping with a die from a bar of metal, or by melting the metal and casting it in a mould. The cheapest rings are made by the last-named method. Very fine and artistic rings are often made by beating and hammering the metal into the desired shape.

MONEY AND ITS QUEER ANCESTORS

SUPPOSE you lived in a country where there was no money. What would you do when you needed something very badly which belonged to someone else? You would probably act just as you do when you want to trade marbles with someone. You would bargain with the other person, showing him that your marble was as good as his. This is no doubt what happens among all primitive peoples who have not yet invented money. We call this form of trading "barter," where one article is exchanged for another.

Bartering, however, is a difficult way to carry on business. If you raise a great many cows and wish to trade some of them for a new farm, it may be hard to find someone who wants the cows and it will undoubtedly be difficult to get the cows to him if he lives a long way off. If, on the other hand, you wish a new pair of shoes, which are worth less than one cow, you have another difficulty to solve; for it is impossible to give half a cow.

The next step in the development of money is therefore the adoption of some small article for exchange which will be easy to carry, will not wear out easily, and will be necessary or desirable among most people.

If you are an Indian you adopt beads or wampum as your money, because everybody wears beads for ornament. When you wish to buy a canoe of another Indian you give him as much wampum as he demands for it. If you live in a country where all the Indians make their living by trapping for furs and skins, you choose skins for your money. You buy of the white man food, ornaments, and knives, and pay him in skins.

In this way many different articles have been used as money in various parts of the world. Tobacco was used in the early Virginia colony. Salt, rice, tea, shells, and precious stones have been used where they proved convenient and available.

It is easy to see how metal finally came to be used as money. It was light, durable, and could be made into pieces of different value if desired. When gold and silver were first used they were exchanged in the form of ornaments, rings, lumps, or bars. Each time a sale was made the metal had to be weighed, and even then the exchange might not always be fair, as other metals were apt to be mixed with the gold or silver.

The first metal coins were made in China about 1200 B.C. and in Lydia, Asia Minor, in the seventh century B.C. The custom grew up of expecting the king or ruler of the country to stamp on the coin some mark telling its weight and purity, so that people might use it without so much bother about weights. When metal coins were once familiar objects it was easy to recognize their value as money, and they are now used in all civilized countries.

In the United States our money-issue is based on

the amount of gold owned by the Government. Coins made of other metals than gold are so-called "token" money; that is, they stand for a certain amount of gold in the United States Treasury, and their money value is higher than their value as metal. The amount of silver in a silver dollar may be worth only fifty cents, but it passes as one dollar because a dollar's worth of gold stands back of it in the treasury. Paper money is another kind of token money which is generally liked better than metal coins. It is lighter and much easier to carry. A paper "bill" (bank note or Treasury note) worth one thousand dollars weighs no more than a one-dollar bill, but one thousand silver dollars, or even five hundred twenty-dollar gold pieces would be very heavy.

The United States Treasury owns three mints where coins are made. These are in Philadelphia, Denver, and San Francisco. The metal which has been bought to be used for coining is first assayed or tested for its purity. It is then refined by means of chemicals until the metal is quite pure. Silver and gold, we have learned, are too soft to be used in their natural state, so they are alloyed or mixed with an exact proportion of copper which has been determined by law. The melted alloy is cast into bars and rolled until thin enough. The bars are annealed or toughened, and are then sent to the cutting machine which cuts out little round blanks like thin lozenges. In the milling machine the edges of the blanks are raised into tiny rims, which will later protect the designs on the coins. The blanks are then sent to the coining press, which

is provided with two hard metal dies or stamps, each bearing the design for one side of the coin. Between these dies the blanks are subjected to enormous pressure and come out bearing the designs which were cut on the dies. They are held in place in the press by a little steel rim or collar which is covered with grooves. These grooves are stamped into the rims of the coins to protect them from theft. Dishonest people might chip off bits from coins and pass them on as full weight if they were not protected by these grooves.

The coins when finished are tested and weighed, and are then stored in great vaults ready to be sent out to banks as needed. The United States Government is extremely particular that all its coins shall weigh just as much as is claimed for them. Each coin is weighed about twenty times during the various stages of its minting.

When old coins become so worn that they no longer can pass as good money, they are returned by banks to the mints where they are remelted and made over into new coins.

The making of paper money is another interesting process and is done by the Bureau of Engraving and Printing in Washington. This money is printed from steel plates which have been carefully cut by skilled engravers from a drawn design. Several men work on a single plate, so that no one man knows exactly how the whole design is made. The paper on which the money is printed is made especially for the Government by a secret process. The finest grade of linen is used and the paper is strengthened by bits of fine silk

thread. It is forbidden by law to use silk in any other kind of paper made; this is to protect us against counterfeit money. The printing is done on hand presses. Sheets of paper large enough for four bills are used. These are cut apart after the printing is completed. The Bureau prints nine million dollars in bills every day, and every bill is counted fifty times during the various processes of its printing. This is of course to insure the Government against loss or theft.

When paper money has been in use about three years it is so worn and dirty that it is no longer fit to remain in circulation. One-dollar bills wear out even sooner than this because they change hands oftener than the larger bills. The bills are returned to Washington, where they are laundered in a special kind of machine. They are starched with a mixture of glue and alum and when dried and ironed look almost as good as new. This prolongs their life six months or more; but when they are sent back to the Bureau a second time they are no longer fit for use. Instead they are carefully counted and are then destroyed in a huge machine which reduces them to paper pulp. This pulp is not fit for making into new money, but is rolled into sheets and sold for various other purposes, often to make pasteboard for binding books.

INTERESTING STORIES IN OTHER BOOKS

MANY stories have been written of the marvels of manufacture and invention. Some of the books which tell these fascinating stories in an interesting way are listed here. You may want to know more about some

of the mysteries of our everyday life than is told in the preceding chapters.

Great Inventors and Their Inventions, by F. P. Bachman. American Book Co.

Story of Glass, by S. W. Bassett. Penn

Story of Leather, by S. W. Bassett. Penn

Story of Lumber, by S. W. Bassett. Penn

Industry and Trade, by A. L. Bishop and A. G. Keller. Ginn

How the World is Clothed, by F. G. Carpenter. American Book Co.

How the World is Housed, by F. G. Carpenter. American Book Co.

How We Are Clothed, by J. F. Chamberlain. Macmillan

How We Are Sheltered, by J. F. Chamberlain. Macmillan

Stories of Industry, by A. Chase and E. Clow. Educational Publishing Co.

Compton's Pictured Encyclopedia. F. E. Compton & Co.

Visit to a Cotton Mill, by A. O. Cooke. Hodder

Day in an Iron Works, by A. O. Cooke. Hodder

Day with Leather Workers, by A. O. Cooke. Hodder

Boys' Own Book of Great Inventions, by F. L. Darrow. Macmillan

Textiles, by W. H. Dooley. Heath

Secret of Everyday Things, by J. H. Fabre. Century

Resources and Industries of the United States, by E. F. Fisher. Ginn

Stories of Useful Inventions, by S. E. Forman. Century

Historic Inventions, by R. S. Holland. Jacobs

Popular History of American Invention, by W. B. Kaempffert. Scribner

The Jewelry Department, by B. E. Kennard. Ronald

Industries of To-day, by M. A. L. Lane. Ginn
The Stationery Department, by M. A. Lehmann. Ronald
Little Tales of Common Things, by I. N. McFee. Crowell
Stories of American Inventions, by I. N. McFee. Crowell
American Inventions and Inventors, by W. A. Mowry and A. M. Mowry. Silver
Romance of Modern Commerce, by H. O. Newland. Seeley
Manufactures, by W. F. Rocheleau. Flanagan
The Cotton and Linen Department, by M. A. Souder. Ronald
The Notion Department, by M. A. Souder. Ronald
Famous Days in the Century of Invention, by G. L. Stone and M. G. Fickett. Heath
Diggers in the Earth, by E. M. Tappan. Houghton
Makers of Many Things, by E. M. Tappan. Houghton
Cotton, by E. Turpin. American Book Co.
Warp and Woof: the Story of the Textile Arts, by E. Very. Educational Publishing Co.
In Storeland, by M. E. Wells. Silver
How It Is Made, by A. Williams. Nelson
Romance of Modern Invention, by A. Williams. Seeley

Many manufacturing firms have written interesting stories of the products which they manufacture. These booklets may usually be obtained free from the companies. They contain many good stories and excellent illustrations showing how things are made. A few of these publications are listed below.

Nothing Takes the Place of Leather. American Sole and Belting Leather Tanners, New York
Magic of Communication. American Telephone and Telegraph Company, New York
From Wool to Cloth. American Woolen Company, Boston
Cork. Armstrong Cork Company, Pittsburgh
Art in Buttons. Art in Buttons, Inc., Rochester, N. Y.

Seven Centuries of Brass Making. Bridgeport Brass Company, Bridgeport, Conn.

The Story Your Ink Bottle Tells. Carter's Ink Company, Boston

The Story of Silk. Cheney Brothers, South Manchester, Conn.

Silk; Its Origin, Culture, and Manufacture. Corticelli Silk Mills, Florence, Mass.

Rubber; Its History and Development. Firestone Tire and Rubber Company, Akron, O.

Pearls of the Mississippi. Hawkeye Pearl Button Company, Muscatine, Ia.

Carpets and Rugs. Hoover Company, North Canton, O.

Three Textile Raw Materials and Their Manufacture. International Acceptance Bank, Inc., New York

News Print: The Origin of Paper Making. International Paper Company, New York

From Tree to Trade. Long-Bell Lumber Company, Kansas City, Mo.

Story of Rope. Plymouth Cordage Company, North Plymouth, Mass.

Glass; History, Manufacture, and Its Universal Applications. Pittsburgh Plate Glass Company, Pittsburgh, Penn.

Story of the Typewriter. Remington Typewriter Company, New York

Box of Wonders in Your Pocket, by DeForest Hulburd. Reprinted from the *American Magazine* and distributed by some local jewelers

Goodyear Welt Shoes; How They Are Made. United Shoe Machinery Corporation, Boston

The Shoe in Romance and History. United Shoe Machinery Corporation, Boston

Rubber from Forest to Foot. United States Rubber Company, New York

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